The Game Lies in the Eye of the Beholder: The Influence of Expertise on Watching Soccer

Michael Smuc (michael.smuc@donau-uni.ac.at)
Eva Mayr (eva.mayr@donau-uni.ac.at)
Florian Windhager (florian.windhager@donau-uni.ac.at)
Research Center KnowComm, Danube University Krems, Dr.-Karl-Dorrek-Str. 30
3500 Krems, Austria

Abstract

The influence of expertise on viewing soccer matches is already an area of extensive research focusing on training. However, free viewing of soccer matches did receive less attention. In an explorative eye-tracking study we compared the viewing behavior of novices, amateur players, and professional players watching soccer scenes freely. Overall, novices seem to view a soccer match quite similar to professional players, whereas amateurs engage in more visual work. The viewing behavior differs when watching soccer freely or with a task in mind – a result worth a second glance.

Keywords: Soccer, viewing behavior, eye tracking, expertise

Introduction

Watching soccer without the corresponding experience and domain knowledge is a real challenge. Without knowledge about standard situations and tactical behavior, an unskilled observer is restricted to following the ball's trajectory mainly. On the other extreme, a good commentator is able to take in the whole scene at once and comment on the events and possible next moves. But what is it that enables an experienced soccer viewer to direct his or her attention more strategically and to take in more relevant information in comparison to an inexperienced one?

To answer this question, we review existing research on eye-movements in sports and their relation to expertise. We present a study that compares the television viewing behavior of soccer laypersons, amateurs, and professional players.

Eye-Movements in Watching Television

In general, viewing television is a complex activity (Josephson & Holmes, 2006): A huge amount of information has to be processed at a speed, which cannot be controlled by the viewer. Kirkorian (2007) assumes that watching television is nearest to perceiving scenes (e.g., Henderson, 2007). Both convey complex visual stimuli, but instead of viewing only one scene, television includes a series of static frames.

To examine visual information processing, *eye tracking* technology provides a means to observe a viewer's point-of-gaze (e.g., Rayner, 1998). In the past, eye tracking focused mainly on scene perception and reading under laboratory conditions (Henderson, 2007; Rayner, 1998); only in the last years, applications in more everyday settings (e.g., Hayhoe & Ballard, 2005; Mayr, Knipfer, & Wessel, 2009) became possible with the emergence of more usable technology.

Central eye-movement measures are fixations and saccades. Saccades are shifts from one point of gaze to another; fixations indicate visual attention to that information (Rayner, 1998). In scene perception, top-down and bottom-up influences control where one looks (Henderson, 2007). Bottom-up influences are stimulus-driven, whereas top-down influences are viewer-driven.

Bottom-up influences are mainly based on the visual salience of the stimulus, i.e., color, saturation, and – which is especially important in television – movement (Mahapatra, Winkler, & Yen, 2008). Also, research on eye-movements during film watching shows that a high degree of the fixations is within the center of the screen (Goldstein, Woods, & Peli, 2007). An open question is whether this is due to a trend to fixate the center or due to movie making conventions placing the most relevant information in the center of the screen.

Top-down influences on the other hand are a viewer's knowledge about the stimulus, his or her domain knowledge, and his or her goals (Henderson, 2003). It was shown that expectations about camera angles, cuts and close-ups determine television viewing behavior (Kirkorian, 2007). These expectations are learned and, therefore, get stronger with viewing experience.

Another top-down influence is the viewer's domain knowledge. Chase and Simon (1973) showed that due to their higher knowledge on possible configurations experts in chess can easier create chunks of information. A similar mechanism can be assumed in soccer experts and was already shown to be influential (Ward & Williams, 2003).

A third top-down influence is the existence of specific goals. Only little research exists on humans watching television freely, i.e. without any task or instruction (see Goldstein et al., 2007, for an exception). However, Spanne (2006) showed that similar to viewing natural scenes (DeAngelus & Pelz, 2009) viewing behavior of movies differs according to the task at hand and in free viewing. But until now no research on free viewing behavior in soccer exists. Rather, most research asked players to anticipate the next move, recall the players' positions (e.g., Ward & Williams, 2003), or actively pass the ball (Helsen & Starkes, 1999).

As watching soccer for leisure purposes is a free viewing condition, it has to be questioned whether existing research

on the influence of expertise on watching soccer with a specific task holds under this condition as well.

Expertise in Soccer and Viewing Behavior

Research on eye-movements in sports focused on the sportsmen's performance and how it relates to perceptual processes mainly (see Memmert, 2009, for a review). The aim of such research was on the one hand to train the sportsmen's viewing behaviour and, thereby, to improve their performance; on the other hand, this research aimed at testing theories of expertise, perception, and attention under ecologically more valid conditions (Casanova, Oliveira, Williams, & Garganta, 2009).

In comparison to amateurs, professional soccer players can better use advance visual cues, they can better recall and recognize visual patterns, they engage in more effective search behaviour, and can better judge situational probabilities (Casanova et al., 2009). With respect to the viewing behaviour, experts have fewer fixations (Helsen & Starkes, 1999), but those last longer than the fixations of amateurs (Williams, 2000). It is assumed that during those longer fixations, experts take in information not only from central, but also from more peripheral areas (Casanova et al., 2009; Ghasemi, Momeni, Rezaee, & Gholami, 2009).

Informative visual cues in soccer are, next to the ball and the goal, the player's teammates and opponents, but also free spaces. Amateurs fixate on the more obvious informative areas only (players, ball), whereas professional players fixate on more sophisticated informative areas like possible free spaces as well (Casanova et al., 2009).

In dependence of the player's position, the number of players visible and the viewers´ tasks, different viewing patterns were observed (Poulter, Jackson, Wann, & Berry, 2005; Williams, Janelle, & Davids, 2003).

Pattern recognition is an important skill in watching games – especially in team sports, like soccer (Ward & Williams, 2003). Experts have a higher repertoire of patterns stored in their long-term memory and can more effectively retrieve appropriate patterns based on visual input (Casanova et al., 2009). Williams, Hodges, North, and Barton (2006) showed that the relation between players and the presence of key players are important features that facilitate pattern recall in soccer experts.

Research Questions

Based on the existing research on expertise in soccer, this study examines free viewing behavior while watching soccer without a concrete task. As prior studies compared only professional and amateur soccer players, we included a third less skilled group in our study: Novices, with little or no knowledge in soccer so far (like Poulter et al., 2005). In detail, we address the following research questions:

Do soccer laypersons, amateurs and professional players differ in their *soccer viewing behavior*? As reported in previous research (Casanova et al., 2009; Williams, 2000) we assume that professional players show less, but longer fixations than amateurs, and that they have better peripheral perception. No hypothesis for novices can be build upon the existing knowledge base.

Do professional soccer players pay more attention to *informative regions* than amateurs? Casanova and colleagues (2009) report that amateurs do focus on less informative regions like the ball and the players. We therefore assume that professional soccer players do fixate more informative regions than amateurs. As the informative content of some visual cues has to be acquired with soccer domain knowledge (e.g., free kick), we hypothesize that novices to soccer do fixate only the most obvious informative regions, i.e. the ball, the player in possession of the ball, and the goal.

Are experts better at *anticipating* the next pass? Ward and Williams (2003) found that professional soccer players are better in predicting the next pass in 11 to 11 simulations. We assume that this superior predictive performance also coincides with fixations on the according player and that amateurs and novices do have less fixations in this area prior to the pass.

Method

The study was conducted in November 2009. Professional soccer players' viewing behavior was recorded at the training camp of their Austrian first league soccer club Magna Wiener Neustadt. The viewing behavior of amateur soccer players and novices was recorded at the Austrian open research night at Danube University Krems.

Sample

The viewing behavior of 7 professional soccer players, 8 amateur soccer players, and 11 soccer novices was recorded. Three participants (1 amateur, 2 novices) with corneal irregularity and varifocals were excluded from further analyses, as there eye gaze data could not be recorded validly. An overall sample of 23 participants remained (see table 1).

The age distribution is similar in all three groups ($F_{2, 22} = 1.43$, $p > .05$). Though more female participants were soccer novices, this difference reached no significance ($\chi^2 = 5.35$, df = 2, $p > .05$).

Table 1: Descriptive statistics.

	professionals	amateurs	novices
N	7	7	9
age	30.9 (5.4)	39.9 (9.6)	33.4 (12.8)
male	100 %	86 %	55 %

Material

Some studies on soccer expertise used recordings from a single camera which takes in the whole soccer field instead of television reports (Vaeyens, Lenoir, Philippaerts, & Williams, 2007; Williams et al., 2006). As our study focuses on watching soccer on television, we used original soccer reports from different not well-known games. We chose

four scenes with an overall duration of 3'43 mins: Scene 1 consists of a cascade of successful passes. Scene 2 is a free kick sequence. Scene 3 deals with a questionable offside decision. Scene 4 shows a quick offense over the whole field.

Measures

Eye movements were recorded using an SMI iView X™ RED eye tracker at a temporal resolution of 60 Hz. It tracks the corneal reflection of the pupils and allows relatively free movement of the head when seated approximately 60 cm from the tracking device. As it allows eye tracking with glasses and contact lenses, a wide range of participants could be included.

Expertise was assessed with multiple questions: whether participants' had experience in actively playing soccer in a club or not, how often they watched soccer on television (never, seldom, several times a year, several times a month), and how they evaluate their own soccer knowledge in comparison to a famous soccer player on a rating scale.

Participants who actively played soccer in a club, watched soccer more frequently by trend ($t = -1.98$, $df = 16$, $p < .1$) and had higher knowledge ($t = 3.12$, $df = 16$, $p < .01$). Therefore, a differentiation based on experience in playing soccer seems to be a valid measure of expertise.

Procedure

Each participant was tested individually. After an explanation on the purpose of the study, the functionality of the eye tracking device was explained to the participants. The device was calibrated using a five-point-calibration. Then the participants were instructed to watch the scenes freely, as they would usually watch soccer.

Participants viewed the soccer scenes on the 17'' computer screen integrated in the eye tracking device. The experimenter was seated next to the participant with a control screen of the participant's gazes to intervene, if the gaze was lost by the eye tracking system (see figure 1).

After viewing the scenes, participants received some questions on demographic data and their soccer expertise.

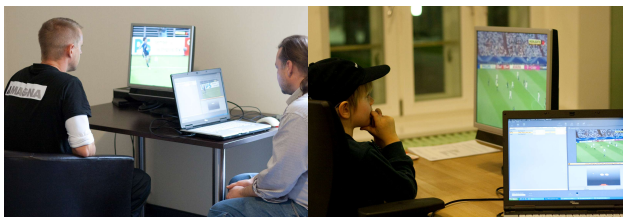

Figure 1: Experiment setup at the training camp (left) and at the long research night (right).

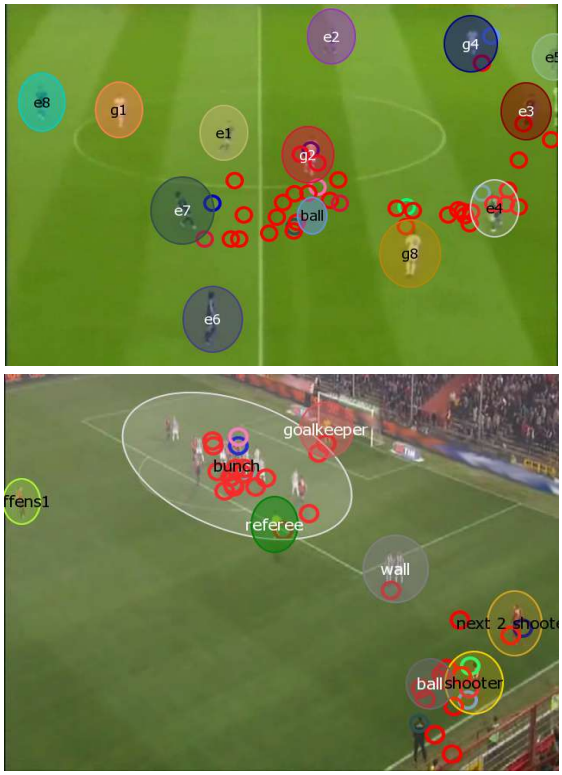

Figure 2: Dynamic AOIs for two frames from the passing scene (top) and the free kick scene (bottom). Filled circles and ellipses denote the dynamic AOIs. The smaller bold rings represent the fixations of amateurs, novices (both red), and professional soccer players (blue, green).

Analyses

Eye tracking data were analyzed with BeGaze™ analysis software. We segmented the videos based on single scenes and extracted the fixations (number, duration) and saccades (number, amplitude).

To analyze the visual attention given to highly informative regions, the soccer scenes were coded in accordance to predefined Areas of Interest (AOIs) similar to Helsen and Starkes (1999), dependent on the scenes. In the following, two of four analyzed scenes are described in detail to exemplify the analysis procedure.

Scene 1 is shown from an overview perspective without close-ups. It consists of a cascade of successful passes for 33 seconds in the middle of the field. At least five players of the offending team and four players of the defending team can be seen. In this scene each player and the ball were coded as an AOI (see figure 2, top). To gain more information on peripheral perception of the ball's surrounding, we used 5 AOIs of different size with the ball at its center. The AOIs' radiuses grew approximately with the size of an average player. As a measure of anticipation, we coded the player who will be the recipient of the next pass as an AOI.

Scene 2 is a free kick sequence next to the goal (13 sec.), representing a typical standard situation in soccer. All players except for three of the offending team can be seen

(see figure 2, bottom). In this free kick situation, the viewers had approximately five seconds to follow the players' prearrangements before the free kick was carried out. The different roles were coded as individual AOIs; namely goalkeeper, referee, free kick shooter, the player next to the free kick shooter, and the bunch of players in front of the goal.

The ability to define dynamic AOIs allowed us to analyze eye movement parameters for each AOI automatically. The main measurements are the number of fixations per AOI, the glance time (where all saccades, including the entry and exit saccade, and all fixation times on an AOI are summed up), and the fixation duration in percent (fixation time in ms divided by the difference of end- and start-time).

Eye tracking data were exported and further analyzed in SPSS to examine differences between professional players, amateur players, and novices in soccer.

Results

Viewing Behavior

As a first indicator of viewing behavior we compared the fixations' number and average duration between the expertise groups across all scenes.

Overall and in contrast to our first assumption, the professional players did not make more fixations than the amateur players ($t = 0.65$, $df = 13$, $p > .05$). Still, as was assumed, their fixations endured longer ($t = -1.99$, $df = 13$, $p < .05$). Interestingly, novices' viewing behavior did not differ from professional players'. But they did make less fixation than the amateur players ($t = 2.37$, $df = 16$, $p < .05$).

Peripheral Perception

As stated earlier, the ball plays the decisive role in soccer and drives the game. Let us take a closer look at the ball and the space around it. As described in the analysis section, we analyzed areas of five different sizes around the ball. The AOI ball 1 equates an AOI with a radius of approximately the size of one player; ball 2 has the radius of two players and so forth.

While the smallest AOI around the ball showed no differences, amateurs differed from the professional players and novices for the bigger ones (see table 2). With increasing size of the AOI ball, professionals fixated this AOI less and had lower glance durations in this AOI. This is an indicator that they perceived the region surrounding the ball already with their central fixation in the nearer ball area; whereas amateurs had to fixate the outer areas as well to take in this information.

As for the overall viewing behavior, we found no remarkable differences between novices and professionals.

Seeking for Relevant Information

For the passing scene (scene 1), the AOIs of the offending and defending players were analyzed for a period of 15 seconds. This analysis offers some details about viewers' visual search patterns for relevant information.

Amateurs more often and longer fixated one player who had a rather longer ball possession time (*amateurs vs. professionals*: glance duration: $t = -2.86$, $df = 13$, $p < .05$; fixation count: $t = -2.98$, $df = 13$, $p < .01$; *novices vs. amateurs*: glance duration $t = -4.28$, $df = 16$, $p < .01$; fixation count. $t = -3.61$, $df = 16$, $p < .01$). One player who was an attractive alternative to pass to was fixated earlier by professionals than by novice viewers ($t = 4.58$, $df = 9$, $p < .01$). This attractive pass alternative had a defensive counterpart who covered him a bit later in the sequence. This defensive player turned out to be an interesting fixation object for professionals in contrast to amateurs (glance duration: $t = -2.63$, $df = 13$, $p < .05$; fixation count: $t = -2.32$, $df = 13$, $p < .05$) For professionals vs. novices a trend exists in the same direction.

As an indicator of anticipation, we also analyzed fixations to the player receiving the next pass prior to ball contact. No difference existed between participants of different expertise in the number of fixations and in their glance duration.

Knowledge-Driven Viewing

Scenes with an inactive ball provide more time for top-down, knowledge-driven processing of the scene. The beginning of scene 2, before the ball was shot, was therefore very interesting to analyze.

Table 2: Eye tracking performance matrix for AOIs of different sizes around the ball. The label of the group with higher values is plotted in case there is a trend. Asterisks denote significant differences.

higher for …		novices or amateurs	novices or profess.	amateurs or profess.
ball 1	glance dur.	-	-	-
	fix. count	-	-	-
	fix. time %	-	-	-
ball 2	glance dur.	amateurs	-	-
	fix. count	amateurs	-	-
	fix. time %	amateurs	-	-
ball 3	glance dur.	amateurs	-	amateurs
	fix. count	amateurs	-	amateurs*
	fix. time %	-	-	-
ball 4	glance dur.	amateurs*	-	amateurs
	fix. count	amateurs*	-	amateurs
	fix. time %	amateurs*	-	-
ball 5	glance dur.	amateurs*	-	amateurs
	fix. count	amateurs*	-	-
	fix. time %	amateurs	-	-

In the free kick sequence (scene 2), professional players fixated free regions (that is, regions without players) longer than amateurs ($t = -2.41$, $df = 13$, $p < .05$). Further, professionals more often fixated the player next to the free kick shooter ($t = -2.62$, $df = 13$, $p < .05$). Both, amateurs' glances (duration: $t = -2.31$, $df = 16$, $p < .05$) and professionals' (duration: $t = -2.21$, $df = 13$, $p < .05$), stayed longer in the area where most players were and where the ball will most likely be played to – in comparison to novices (see figure 2, bunch at the bottom). No significant differences were found between professionals, amateurs and novices in their viewing behavior on the goalkeeper, the free kick wall, the referee, and actions of single offensive or defensive players.

Discussion

Watching a soccer match freely is an everyday activity that is not connected to any task. Prior research on viewing behaviour during watching soccer was insofar restricted as participants were asked to answer questions, anticipate behaviour, or recall information (e.g., Ward & Williams, 2003). Human eye-movements in a free viewing condition of moving visual stimuli were recorded only seldom until now (Mayr et al., 2009; Spanne, 2006) and never for watching a soccer match. This study is the first to analyse the influence of expertise on viewing behaviour.

Still, some of the results which were gained under task conditions hold under free viewing as well: We observed longer fixations in professional than in amateur players like found in many other studies (Casanova et al., 2009, Williams, 2000). In addition, they exhibited higher peripheral perception skills like reported in prior research (Casanova et al., 2009; Ghasemi et al., 2009): Professional players fixate less often the wider area surrounding the ball compared to amateurs. Fewer fixations do not mean that professionals perceive less parts of the game but rather that they perceive more relevant visual cues with fewer fixations.

We assumed that professional soccer players pay more attention to informative regions. This top-down controlled viewing behaviour should increase with higher domain knowledge. Indeed, we ascertained that professional players fixated some informative regions (certain key players, free regions) which amateurs fixated only to a lesser extent. Other areas, like the bunch of players during the free-kick, were perceived by professional and amateur players to a similar extent. Due to our comparison with novices we could show that this perception is knowledge-driven as well.

In contrast to prior research, we observed some profound differences as well: Our assumption that professional players would anticipate the next pass visually is not supported by our participants' viewing behaviour. It remains to be studied whether this difference is due to the absence of an according task or due to the short duration of the analysed scene. Further analyses of longer sequences would be necessary to validate this finding.

In contrast to prior research (Casanova et al., 2009; Williams, 2000) we found no differences between the number of fixations by amateurs and professionals. As this visual indicator depends on the number of players displayed in a scene (see Vaeyens et al., 2007), a more differentiated analysis might reveal differences according to the proportion of the field displayed.

Prior research on *soccer expertise* compared only professionals with high and low performance (e.g., Vaeyens et al., 2007), professionals with amateurs (e.g., Ward & Williams, 2003), or people with high vs. low self-reported soccer knowledge (Dijksterhuis, Bos, van der Leij, & van Baarne, 2009). To our knowledge barely any research extended these boundaries of expertise so far to include also professional soccer observers (like referees, see Ghasemi et al., 2009, for an exception) or novices without any soccer knowledge (see Poulter et al., 2005, for an exception). Though the first gap remains to be filled, this study was able to shed some light on the viewing behaviour of novices:

In contrast to our assumption that novices would mainly focus on the ball (as the most obvious, and highly salient informative region) they watched similarly to professional soccer players. A possible explanation for this similarity could be that though they looked on the same region, they extracted different information.

Novices as well as professionals focused on the ball less time than the amateur players. This result raises the question, why amateurs do view a soccer match differently from professional players and novices? Maybe the amateurs were very motivated to compare their own gazes to those of professionals in comparison to the more carefree novices. They seemed to seek for as much information as possible, especially in regions of 8-10 meters around the ball. They also had a higher fixation dispersion than professionals and novices ($F_{2,21} = 3.34$, $p < .1$). Another explanation could be that the situation was not as goal-free as intended, because different learned viewing behaviors were activated: Professional soccer players frequently watch soccer matches to analyze their behavior for training purposes. Amateur soccer players in contrast watch the game not only to "read" it, but mainly to reach the soccer fan's "fever pitch".

Limitations

This study is limited by the artificial experimental setting of watching a match in front of a computer screen instead of a wide-screen television (cp. Josephson & Holmes, 2006). Even though nowadays soccer matches are often watched on youtube, a typical match-viewing situation is characterized by a stimulating, emotion-rich environment.

A second limitation of our results is the methodology used: Eye tracking methodology can only show the gaze focus, but not the focus of attention (e.g., Treisman, 2006). A triangulation with other methodologies would be necessary, but would restrict the free-viewing paradigm.

Further Research Questions

One of the main novelties in this study is the free viewing paradigm applied to watching soccer. It would be interesting – also in the sense of the limitations – to analyze free viewing in different environments (i.e., stadium, private TV, public viewing areas).

Qualitative analysis of the professional players' viewing behavior indicated differences between playing positions: Whereas goal keepers observed the behavior of the goal keepers to a higher extent, trainers scanned the soccer field more frequently. A more differentiated analysis of experts is needed (see also Casanova et al., 2009).

Further research should also compare passive sport experts, i.e. real viewing experts (e.g., referees – see Ghasemi et al., 2009) vs. couch potatoes, and active sport experts, i.e. professional vs. amateur players, in their viewing behavior.

Soccer is a male-biased sport – and so is research on it. With one exception (Poulter et al., 2005), no women were included in prior studies on soccer expertise. We would therefore like to encourage further research on female soccer players and their passive counterparts.

Acknowledgments

We are grateful for the willingness of the SC Magna Wiener Neustadt's players to participate in this study. Further thanks are given to the visitors at the "Lange Nacht der Forschung 09" (the Austrian open research night) for their interest and to ecoplus for supporting our travel expanses.

References

Casanova, F., Oliveira, J., Williams, M., & Garganta, J. (2009). Expertise and perceptual-cognitive performance in soccer: A review. *Revista Portuguesa de Ciências do Desporto*, *9*, 115-122.

Chase, W. G., & Simon, H. A. (1973). Perception in chess. *Cognitive Psychology*, *4*, 55-81.

DeAngelus, M., & Pelz, J. (2009). Top-down control of eye movements: Yarbus revisited. *Vis Cognition*, *17*, 790-811.

Dijksterhuis, A., Bos, M. W., van der Leij, A., & van Baarne, R. B. (2009). Predicting soccer matches after unconscious and conscious thought as a function of expertise. *Psychological Science, 20*, 1381-1387.

Ghasemi, A., Momeni, M., Rezaee, M., & Gholami, A. (2009). The difference in visual skills between expert versus novice soccer referees. *Journal of Human Kinetics*, *22*, 15-20.

Goldstein, R. B., Woods, R. L., & Peli, E. (2007). Where people look when watching movies: Do all viewers look at the same place? *Computers in Biology & Medicine*, *37*, 957-964.

Hayhoe, M., & Ballard, D. (2005). Eye movements in natural behavior. *Trends in Cognitive Science*, *9*, 188-194.

Helsen, W. F., & Starkes, J. L. (1999). A multidimensional approach to skilled perception and performance in sport. *Applied Cognitive Psychology*, *13*, 1-27.

Henderson, J. M. (2007). Regarding scenes. *Current Directions in Psychological Science*, *16*, 219-222.

Josephson, S., & Holmes, M. E. (2006). Clutter or content? How on-screen enhancements affect how TV viewers scan and what they learn. In *Proceedings of the 2006 symposium on Eye tracking research &; applications* (pp. 155-162). San Diego, CA: ACM.

Kirkorian, H. L. (2007). *Age differences in eye movements during video viewing*. Dissertation, University of Massachusetts Amherst.

Mahapatra, D., Winkler, S., & Yen, S. C. (2008). Motion saliency outweighs other low-level features while watching videos. In *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*, *6806*, 68060P1-68060P10.

Mayr, E., Knipfer, K., & Wessel, D. (2009). In-sights into mobile learning. An exploration of mobile eye tracking methodology for learning in museums. In G. Vavoula, N. Pachter, & A. Kukulska-Hulme (Eds.), *Researching mobile learning: Frameworks, methods, and research designs* (pp. 189-204). Oxford, UK: Peter Lang.

Memmert, D. (2009). Pay attention! A review of visual attentional expertise in sport. *International Review of Sport and Exercise Psychology*, *2*, 119-138.

Poulter, D. R., Jackson, R. C., Wann, J. P., & Berry, D. C. (2005). The effect of learning condition on perceptual anticipation, awareness, and visual search. *Human Movement Science*, *24*, 345-361.

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, *124*, 372-422.

Spanne, J. G. (2006). *Task impact on cognitive processing of narrative fiction film*. Master thesis, Lund University.

Treisman, A. (2006). How the deployment of attention determines what we see. *Visual Cognition*, 14, 411-443.

Vaeyens, R., Lenoir, M., Philippaerts, R. M., & Williams, A. M. (2007). Mechanisms underpinning successful decision making in skilled youth soccer players: An analysis of visual search behaviors. *Journal of Motor Behavior, 39*, 395-408.

Ward, P., & Williams, A. M. (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 team games: Research, theory, and practice. In *INSEP 2000* (p. 15-16).

Williams, A. M. (2002). Eye movement measurement systems and key visual search parameters. *Expertise in Elite Sports*, 43.

Williams, A. M., Hodges, N. J., North, J. S., & Barton, G. (2006). Perceiving patterns of play in dynamic sport tasks: Investigating the essential information underlying skilled performance. *Perception, 35*, 317-332.

Williams, A. M., Janelle, C. M., & Davids, K. (2003). Constraints on the search for visual information in sports. *Journal of Sport & Exercise Psychology, 2*, 301-318.