Perceptual-Cognitive Skills and Their Interaction as a Function of Task Constraints in Soccer

André Roca,1 Paul R. Ford,1 Allistair P. McRobert,1 and A. Mark Williams2

1Liverpool John Moores University; 2Brunel University

The ability to anticipate and to make decisions is crucial to skilled performance in many sports. We examined the role of and interaction between the different perceptual-cognitive skills underlying anticipation and decision making. Skilled and less skilled players interacted as defenders with life-size film sequences of 11 versus 11 soccer situations. Participants were presented with task conditions in which the ball was located in the offensive or defensive half of the pitch (far vs. near conditions). Participants’ eye movements and verbal reports of thinking were recorded across two experiments. Skilled players reported more accurate anticipation and decision making than less skilled players, with their superior performance being underpinned by differences in task-specific search behaviors and thought processes. The perceptual-cognitive skills underpinning superior anticipation and decision making were shown to differ in importance across the two task constraints. Findings have significant implications for those interested in capturing and enhancing perceptual-cognitive skill in sport and other domains.

Keywords: expertise and expert performance, eye movements, verbal reports, situational task constraints

Over recent years, there has been significant interest in identifying the skills and mediating processes that contribute to superior anticipation and decision making in sport (e.g., see Hodges & Williams, 2012; Starkes & Ericsson, 2003; Williams & Ford, 2008). It has been reported that experts have superior perceptual-cognitive skills compared with novices, enabling them to use vision and other senses to identify and recognize information in the environment for integration with existing knowledge to select and execute decisions. These perceptual-cognitive skills include (a) postural cue usage, which is the ability to pick up early visual information from an opponent or teammate’s body movements ahead of a key event (e.g., Müller, Abernethy, & Farrow, 2006; Williams & Davids, 1998); (b) pattern recognition, which is the capacity to recognize familiarity and structure in an evolving pattern of play early in its development (e.g., Tenenbaum, Levy-Kolker, Sade, Liebermann, & Lidor 1996; Williams, Hodges, North, & Barton 2006); and (c) situational probabilities, which is the ability to formulate “a priori” expectations/probabilities of the potential options that might occur in any given situation (e.g., Crognier & Féry, 2005; Ward & Williams, 2003).

The majority of researchers have used a reductionist approach to capture and examine each perceptual-cognitive skill in isolation from the others, with a stronger emphasis on experimental control rather than ecological validity or representative task design (Williams, 2009). For example, Williams et al. (2006) examined pattern recognition skill by presenting adult soccer players with film sequences of match play involving either structured attacking sequences or unstructured arrangements of players. Skilled players were faster and more accurate than less skilled participants at recognizing structured sequences of play early in their development, whereas there were no between-group differences when recognizing unstructured sequences of play. Several other researchers have focused on postural cue usage (e.g., Franks & Hanvey, 1997; McMorris & Colenso, 1996; Savelsbergh, van der Kamp, Williams, & Ward, 2005; Williams & Burwitz, 1993). Ward and Williams (2003) examined the ability of elite and novice soccer players to use situational probabilities. Players were presented with film sequences of match play that were frozen at key moments during the action. Participants were required to highlight the key players in a good position to receive the ball and to rank each option in order of likelihood. The elite players were more accurate than the subelite group at assigning appropriate “a priori” situational probabilities to the events likely to unfold. The use of these types of reductionist approaches has led to important insights into how each of the different perceptual-cognitive skills contributes to performance. However, it is likely that their function is not mutually

André Roca, Paul R. Ford, and Allistair P. McRobert are with the Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK. A. Mark Williams is with the Centre for Sports Medicine and Human Performance, Brunel University, London, UK.
exclusive and that these skills interact with each other in a dynamic manner during performance (Williams & Ward, 2007). A better understanding is needed of how the different perceptual-cognitive skills interact during performance and how their relative importance varies as a function of the constraints of the task environment.

The ability to anticipate and to make decisions is at least partly determined by the visual search behaviors and cognitive thought processes employed. Some tentative evidence exists to suggest that the use of such processes differs depending on the specific task constraints. For example, in separate experiments, Williams and colleagues (e.g., Williams & Davids, 1998; Williams, Davids, Burwitz, & Williams, 1994) examined the search behaviors adopted by skilled and less skilled defenders when viewing film-based simulations of defensive scenarios in soccer involving varying numbers of players (i.e., 11 vs. 11, 3 vs. 3, and 1 vs. 1 situations). During the 11 versus 11 situations, skilled players employ more fixations of shorter duration than their less skilled peers, with gaze allocated to more peripheral areas of the display such as the positions and movements of players. In contrast, less skilled players tend to fixate more frequently on the ball and the player in possession of the ball. When viewing the 3 versus 3 simulations, players typically employ fewer fixations of longer duration compared with 11 versus 11 situations, mainly fixating on the player in possession of the ball or the ball itself with relatively few fixations to disparate areas of the display. During 1 versus 1 situations, skilled players employ a higher frequency of fixations between the hip and ball foot region compared with less skilled players, who fixate largely on the ball.

Similarly, Vaeyens, Lenoir, Williams, Mazyn, and Philippaerts (2007a, 2007b) analyzed the visual search behaviors employed by youth players when player numbers were altered across different microstates of offensive play in soccer (i.e., 2 vs. 1, 3 vs. 1, 3 vs. 2, 4 vs. 3, and 5 vs. 3 simulations). When players are presented with the 2 versus 1 and 3 versus 1 offensive simulations, they employ a smaller number of fixations of longer duration mostly toward the ball or the player in possession of the ball. In contrast, a higher number of fixations of shorter duration and to more disparate perceptual information sources are employed during the situations with more players (3 vs. 2, 4 vs. 3, and 5 vs. 3) compared with the other conditions. The number of players involved in a situation affects visual search rate variables, such as the frequency, location, and duration of fixations.

Although these papers report successful attempts to systematically manipulate certain situational task constraints, they have only focused on the visual sources of information that athletes use to guide performance. There have been no attempts to provide a window into the cognitive processes that mediate anticipation and decision making when task constraints are manipulated in the performance environment, particularly in team ball sports such as soccer. A few researchers have started to explore the cognitive processes mediating superior performance, albeit without any direct manipulation of task-specific constraints (e.g., North, Ward, Ericsson, & Williams, 2011; Roca, Ford, McRobert, & Williams, 2011; Ward, Williams, & Ericsson, 2003). For example, Roca et al. (2011) used a video-based simulation of 11 versus 11 defensive sequences of soccer play to examine how visual search and cognitive processes impact on anticipation and decision making. Skilled players made more fixations of shorter duration and on significantly more locations in the display compared with less skilled participants. Moreover, the skilled players had more higher-order cognitive thoughts involving prediction, evaluation, and decisional planning, rather than those that merely monitored current actions and events. However, Roca et al. (2011) did not involve any manipulation of situational task constraints and there have been few, if any, studies involving manipulations of key task constraints other than player numbers, such as the position of the ball and players on the field of play (Williams & Ericsson, 2005).

We examine anticipation and decision making in skilled and less skilled soccer players. In particular, we examine the role of, and interaction between, various perceptual-cognitive skills (i.e., postural cue usage, pattern recognition, and situational probabilities) when making these judgments. A representative film-based simulation is employed involving 11 versus 11 soccer situations from a defensive player’s perspective and under two novel situational task constraints where the ball is either far away from (far task) or close to (near task) the observer. A combination of eye movement data (Experiment 1) and retrospective verbal reports of thinking (Experiment 2) are collected to garner more detailed knowledge of the perceptual-cognitive skills and processes underpinning superior performance and how they may differ across these unique task constraints.

**Experiment 1**

In Experiment 1, differences in visual search behaviors as well as anticipation and decision-making performance are examined across two distinct game situations in soccer in which the ball is either far away from or close to participants. We predicted that skilled soccer players would record superior anticipation and decision making when compared with less skilled counterparts. We hypothesized that during the far task condition, in which the ball was far away from the participant, skilled players would employ more fixations of shorter duration to more informative areas in the scene (e.g., 11 vs. 11 situations, Roca et al., 2011; Williams et al., 1994). In the near task, in which the ball was close to the participant, skilled participants were expected to have fewer fixations of longer duration, predominantly to the player in possession of the ball (i.e., temporally constrained situations comparable to the micro-states of play from Vaeyens et al., 2007a, 2007b; Williams & Davids, 1998). For less skilled participants, we expected no significant differences in the search rate and gaze strategy employed across task conditions due to their lack of domain- and task-specific knowledge compared with their more skilled counterparts (Williams & Ford, 2008).
Methods

Participants
Twenty-four adult male soccer players were recruited. Skilled participants \((n = 12; \text{age } M = 23.1 \text{ years, } SD = 3.7)\) were professional \((n = 6)\) and semiprofessional \((n = 6)\) players. They had been playing soccer for an average of 14.4 years \((SD = 3.1)\), during which they had trained/played for a mean of 9.7 hr \((SD = 2.4)\) per week and participated in an average of 720 \((SD = 133)\) competitive matches. Less skilled players \((n = 12; \text{age } M = 24.1 \text{ years, } SD = 2.2)\) had participated only at an amateur or recreational level. The less skilled players had taken part in soccer infrequently for an average of 11.0 years \((SD = 4.2)\), participating in a mean of 90 matches \((SD = 79)\) and averaging 1.5 hr \((SD = 1.5)\) per week in practice. Participants provided informed consent and the research procedures were conducted according to the ethical guidelines of the lead institution.

Stimuli
Participants were presented with a representative task involving life-size video sequences of dynamic, 11 versus 11 soccer situations filmed and viewed from the perspective of a central defender (see Roca et al., 2011). A panel of three Union of European Football Associations (UEFA)–qualified soccer coaches independently examined and selected a total of 20 video action stimuli. These action sequences were subdivided into two conditions termed far and near task. In half of the situations the ball was far away from the participant (i.e., far task), whereas in the other half the ball was close to the participant (i.e., near task). In the far task condition the attacking team was in possession of the ball only in their defensive half, whereas in the near task situation the action started and finished in their offensive half of the pitch (see Figure 1a and b). Only those sequences approved unanimously by the coaches were included. Sequences of play lasted approximately 5 s and were occluded at a key moment in the action (e.g.,

![Figure 1](a)  
![Figure 1](b)

Figure 1 — A final frame extracted from a typical trial at the (a) “far task” and (b) “near task” condition.
player in possession of the ball about to make an attacking pass, shoot at goal, or maintain possession of the ball by dribbling forward). The far and near situation stimuli were presented randomly, with the order being consistent across all participants.

**Procedure**

The action sequences were presented using a rear projection video system (Hitachi ED-A101, Yokohama, Japan) onto a 3.7 m x 2.7 m large screen (Draper Cinefold, Spiceland, IN, USA). Participants started each of the video stimuli in a standing position at a distance of approximately 2.5 m from the screen. They were required to take the place of the central defender in relation to the screen footage and to move/interact with the footage as if playing in that position in a competitive soccer match.

A mobile eye-tracking system (Applied Science Laboratories, Bedford, MA, USA) was used to record visual point of gaze. The Mobile Eye consists of a video-based monocular system that measures eye point of gaze with respect to a head-mounted scene camera. The system measures the relative position of the pupil and corneal reflection in relation to each other. The result is a computed point of gaze superimposed as a cursor onto the scene image captured by the head-mounted camera optics. The data were analyzed frame by frame using SportsCode Gamebreaker V8 software (Sportstec, Sydney, Australia). System accuracy was ± 1° visual angle, with a precision of 1° in both horizontal and vertical fields.

Before testing, each participant was given an overview of the experiment and the eye movement system was fitted onto the head. The system was calibrated using a reference of six to nine nonlinear points on the scene image so that the fixation mark corresponded precisely to the participant’s point of gaze. The calibration procedure was periodically checked between trials to ensure system accuracy. Participants were presented with four warm-up trials to ensure familiarity with the experimental setup. At the end of each video stimuli, the participant’s accuracy of anticipation and decision-making judgments at occlusion were verbally recorded. Participants received 20 test trials and the entire test protocol was completed in approximately 45 min.

**Outcome Data Analysis**

Anticipation accuracy was defined as whether the participant correctly selected the next action of the player in possession of the ball at the moment of video occlusion, such as he passed to a particular teammate, shot at goal, or continued dribbling the ball. For the decision-making measure, the panel of UEFA-qualified soccer coaches independently selected the most appropriate decision for a participant to execute in response to the on-screen action at the moment of video occlusion. The accuracy was defined as whether the action selected by the participant corresponded to the most appropriate decision for that trial. The interobserver agreement between coach selections was 91.7%.

The anticipation and decision-making accuracy were calculated as the mean number of trials (in percentages) in which the participant made the correct response. The outcome scores on each of the two measures were analyzed separately using a factorial two-way ANOVA with Group (skilled, less skilled) as the between-participant factor and Task Condition (far, near task) as within-participant factors.

**Visual Search Data Analysis**

The three most discriminating trials for each of the far and near task conditions, making six trials in total were subjected to visual search analysis (cf. McRobert, Williams, Ward, & Eccles, 2009). Discriminating trials were chosen based on the greatest between-group differences in mean outcome scores combined for both response accuracies.

**Search Rate.** Three measures of search rate were examined, namely, the mean number of fixations per trial, the mean number of fixation locations per trial, and mean fixation duration (in milliseconds). A fixation was defined as a condition in which the eye remained stationary within 1.5° of movement tolerance for a period equal to, or in excess of, 120 ms or three video frames (Williams & Davids, 1998). The three dependent variables were analyzed separately using a factorial two-way ANOVA with Group (skilled, less skilled) as the between-participant factor and Task Condition (far, near) as within-participant factors.

**Percentage Viewing Time.** Percentage of total viewing time spent fixating various areas of the display was analyzed. The display was initially divided into six fixation locations: player in possession of the ball; ball (i.e., ball flight); opponent player; teammate player; space (i.e., areas of free space on the pitch in which no player is located); and an unclassified category for fixations that did not match with the aforementioned locations. The uncategorized category was eventually excluded because none of participants’ fixations fell outside any of the other five locations. Percentage viewing time data were analyzed using a factorial three-way ANOVA with Group (skilled, less skilled) as the between-participant factor and Task Condition (far, near) and Fixation Location (player in possession of the ball, ball, opponent, teammate, space) as within-participant factors.

The visual search data were coded on two separate occasions by the primary investigator to evaluate intraobserver reliability, with a random sample of six participants (three skilled and three less skilled participants) being coded a third time by an independent investigator for interobserver reliability. The three most discriminating trials for each of the far and near task conditions (i.e., making six trials in total) were reanalyzed. The reliability of the visual search data were 95.2% for intra- and 91.0% for interobserver agreement (see Thomas, Nelson, & Silverman, 2005). For any repeated-measures ANOVA,
Greenhouse–Geisser procedures were used to correct for violations of the sphericity assumption. Effect sizes were reported as partial eta squared ($\eta^2$). Any significant main and interaction effects were followed up using Bonferroni-corrected pairwise comparisons and Tukey’s HSD post hoc tests, respectively. The alpha level was set at $p < .05$.

## Results and Discussion

### Outcome Data

Skilled participants were more accurate than less skilled participants in anticipating the actions of their opponents ($M = 68.3\%$, $SD = 7.2$ vs. $M = 37.5\%$, $SD = 6.6$), $F(1, 22) = 120.47$, $p < .001$, $\eta^2 = .85$. Skilled participants were also more accurate than less skilled in deciding on how to respond to each game-situation ($M = 80.8\%$, $SD = 5.1$ vs. $M = 49.2\%$, $SD = 9.7$), $F(1, 22) = 99.28$, $p < .001$, $\eta^2 = .82$. The mean values suggest that successful decision making was not always preceded by successful anticipation. There was a significant main effect for type of task in anticipation accuracy, $F(1, 22) = 20.13$, $p < .001$, $\eta^2 = .48$. Participants were more accurate in anticipating the actions of opponents during the near task ($M = 61.7\%$, $SD = 19.0$) compared with the far task situations ($M = 44.2\%$, $SD = 19.9$). No other significant main or interaction effects were reported; all $F < 1.23$, $p < .28$, $\eta^2 < .05$. Findings support previous research using realistic film simulations of soccer situations to independently measure anticipation (Ward & Williams, 2003; Williams et al., 1994) and decision making (Helsen & Starkes, 1999; Vaeyens et al., 2007a).

### Visual Search Data

**Search Rate.** The mean data for search rate variables are presented in Table 1. There were significant skill-based differences in the mean fixation duration, $F(1, 22) = 40.16$, $p < .001$, $\eta^2 = .65$, the mean number of fixations, $F(1, 22) = 76.41$, $p < .001$, $\eta^2 = .78$, and mean number of fixation locations per trial, $F(1, 22) = 75.12$, $p < .001$, $\eta^2 = .77$. The visual search behavior of skilled players involved more fixations ($M = 11.06$, $SD = 3.46$ vs. $M = 6.32$, $SD = 1.32$) of shorter duration ($M = 465$ ms, $SD = 200$ vs. $M = 811$ ms, $SD = 183$) to significantly more locations in the visual display ($M = 5.72$, $SD = 1.92$ vs. $M = 3.32$, $SD = 0.76$) when compared with the less skilled players. There was also a significant main effect for task condition on fixation duration, $F(1, 22) = 27.66$, $p < .001$, $\eta^2 = .56$, the average number of fixations, $F(1, 22) = 132.33$, $p < .001$, $\eta^2 = .86$, and average number of fixation locations per trial, $F(1, 22) = 52.92$, $p < .001$, $\eta^2 = .71$. Participants made more fixations ($M = 10.48$, $SD = 3.86$ vs. $M = 6.90$, $SD = 1.96$) of shorter duration ($M = 539$ ms, $SD = 246$ vs. $M = 737$ ms, $SD = 234$) and on more locations in the display ($M = 5.42$, $SD = 2.33$ vs. $M = 3.63$, $SD = 0.79$) during the far task when compared with the near task condition.

Significant Group × Task Condition interaction effects were observed for the mean fixation duration, $F(1, 22) = 4.42$, $p = .047$, $\eta^2 = .17$, the mean number of fixations, $F(1, 22) = 50.49$, $p < .001$, $\eta^2 = .70$, and mean number of fixation locations per trial, $F(1, 22) = 31.05$, $p < .001$, $\eta^2 = .59$. Post hoc testing revealed that skilled players used significantly more fixations of shorter duration and toward greater number of locations when interacting with the far task compared with the near task condition. In contrast, less skilled players only showed a between-task condition difference for more fixations in the far compared with near condition, whereas there was no task-based differences in the average fixation duration and number of fixation locations per trial. These data support previous published reports that employed a between-participants design to independently analyze visual search behaviors when players viewed simulations of the whole field of play (i.e., 11 vs. 11 simulations; e.g., Williams et al., 1994) compared with micro situations within the game (e.g., 3 vs. 3, 3 vs. 1, or 2 vs. 1 situations; see Vaeyens et al., 2007a, 2007b; Williams & Davids, 1998).

**Percentage Viewing Time.** The mean data for percentage viewing time are presented in Figure 2. There was a significant main effect for fixation location, $F(2, 35, 51.72) = 219.26$, $p < .001$, $\eta^2 = .91$. Bonferroni-corrected pairwise comparisons demonstrated that participants spent significantly more time fixating the player in possession of the ball ($M = 56.4\%$, $SD = 16.9$) in comparison with any other fixation location. This was followed by fixations on the ball ($M = 17.3\%$, $SD = 15.0$) and opponents ($M = 12.5\%$, $SD = 10.9$), respectively. No difference was evident between fixations on teammates ($M = 6.5\%$, $SD = 6.4$) and areas of free space ($M = 7.4\%$, $SD = 8.6$). There was also a significant Group × Fixation Location interaction effect, $F(2, 35, 51.72) = 27.55$, $p < .001$, $\eta^2 = .56$. 

### Table 1  Mean (SD) Number of Fixations, Number of Fixation Locations, and Fixation Duration per Trial Across Groups and Task Conditions

<table>
<thead>
<tr>
<th>Search Rate</th>
<th>Far Task</th>
<th>Near Task</th>
<th>Far Task</th>
<th>Near Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of fixations</td>
<td>13.95 (1.92)</td>
<td>8.17 (1.85)</td>
<td>7.01 (1.23)</td>
<td>5.64 (1.05)</td>
</tr>
<tr>
<td>No. of fixation locations</td>
<td>7.31 (1.37)</td>
<td>4.14 (0.58)</td>
<td>3.53 (0.83)</td>
<td>3.11 (0.64)</td>
</tr>
<tr>
<td>Fixation duration (ms)</td>
<td>332 (61)</td>
<td>598 (205)</td>
<td>745 (174)</td>
<td>877 (173)</td>
</tr>
</tbody>
</table>
Post hoc testing showed that skilled participants spent significantly more time fixating on the opponents ($M = 19.3\%, SD = 11.2$) and areas of free space ($M = 12.5\%, SD = 9.7$) when compared with the less skilled group ($M = 5.6\%, SD = 4.2$ and $M = 2.3\%, SD = 2.0$, respectively). In contrast, less skilled players spent significantly more time fixating the player in possession of the ball ($M = 60.6\%, SD = 14.1$) and the ball’s course of action ($M = 28.1\%, SD = 13.7$) compared with the skilled players ($M = 52.2\%, SD = 18.6$ and $M = 6.4\%, SD = 5.2$, respectively).

A significant Group $\times$ Task Condition $\times$ Fixation Location interaction was observed, $F(2.06, 45.23) = 5.45$, $p = .007$, $\eta^2_p = .20$. Post hoc testing revealed that in the far task, skilled players spent more time fixating teammates, opponents, and areas of free space combined ($M = 54.7\%, SD = 12.2$ vs. $M = 28.0\%, SD = 7.0$), whereas in the near task, they spent more time fixating the player in possession of the ball ($M = 67.8\%, SD = 7.4$ vs. $M = 36.6\%, SD = 8.7$). In comparison, less skilled participants showed no significant differences for the time spent fixating on the different locations of the display between the far and near task conditions. No other main or interaction effects were significant; all $F \leq 0.31$, $p \geq .58$, $\eta^2_p \leq .01$.

A number of systematic differences in visual search behavior as a function of skill level and the unique constraints of the task were highlighted. Skilled soccer players employ different search strategies when viewing the whole field of play (i.e., far task) compared with
more microstates of play (i.e., near task). When the ball
is far away from the player, they use a search pattern
involving more frequent fixations of shorter duration to
more disparate and informative display areas. In con-
trast, when the ball is closer to the player, they employ
lower search rates, generally fixating gaze centrally on
the player in possession of the ball, potentially relying
on peripheral vision to monitor other players’ move-
ments (see Williams & Davids, 1998). Findings support
and extend previous work (e.g., Vaeyens et al., 2007a,
2007b; Williams et al., 1994) showing that visual search
patterns are affected by the constraints of the task as
well as the skill level of the performer. The manipu-
alation of the distance between the ball and player and/or
goal resulted in a more complete representation of the
processes mediating expertise in dynamic, 11 versus 11
open play situations in soccer.

Experiment 2

In Experiment 2, the thought processes that underpin
anticipation and decision-making expertise across the
near and far tasks were examined. We hypothesized
that skilled players would verbalize a greater number of
cognitive verbal statements compared with lesser skilled
players, which would be evidence of more enhanced
domain-specific memory representations (North et al.,
2011; Roca et al., 2011; Ward et al., 2003). Moreover,
we expected that due to the more attention-demanding
and temporal pressure situation of the near task, skilled
players would articulate a greater number of higher-order
cognitive statements when compared with the far task
condition.

Particular attention was given for the first time in
the literature to examining how the different perceptual-
cognitive skills interact during performance as a function
of the unique constraints imposed by the task situation.
An analysis involving a new classification scheme of
verbal reports was specifically developed to examine the
interaction between perceptual-cognitive skills. We
hypothesized that the importance of these skills would
alter significantly depending on the specific constraints
of the task (Williams, 2009). Our hypothesis was based
on the results of Experiment 1 and findings reported
previously involving the recording of eye movement
behavior during different game constraints in soccer
(e.g., Vaeyens et al., 2007a; Williams & Davids, 1998;
Williams et al., 1994). According to these findings, dif-
ferent search strategies are employed when viewing the
whole field of play (i.e., far task; 11 vs. 11 simulations)
compared with more time-constrained microsituations
of the performance setting (e.g., near task; 3 vs. 3 or 1
vs. 1 duels). It was predicted that in the far task, players
would be expected to rely on pattern recognition skills
due to the need to fixate on multiple players in this con-
dition during Experiment 1. In the near task, they were
expected to rely on postural cue usage due to the need to
fixate on the player in possession of the ball in Experi-
ment 1. Finally, there is comparatively little research
on situational probabilities and the work that exists has
typically identified skill-based differences rather than
exploring whether the importance of these probabilities
differ from one situation/task to another. Consequently,
no predictions were made for the relative importance of
situational probabilities across task conditions.

Methods

Participants

A new sample of 24 adult male soccer players par-
ticipated. Participants were of the same skill level as the
sample in Experiment 1. Skilled participants (n = 12; age
M = 23.6 years, SD = 4.4) were professional (n = 7) and
semiprofessional (n = 5) players. They had an average of
14.8 years (SD = 3.9) of playing experience, during which
they had trained/played for a mean of 10.3 hr (SD = 2.6)
per week and participated in an average of 730 (SD = 138)
competitive matches. Less skilled players (n = 12; age M
= 24.5 years, SD = 3.7) had not participated in the sport
above amateur or recreational level. They had taken part
in soccer irregularly for an average of 11.3 years (SD =
3.2), including participation in a mean of 80 matches (SD
= 74). They currently played for an average of 1.7 hr (SD
= 1.6) per week. Participants provided informed consent
and the research procedures were conducted according to
the ethical guidelines of the lead institution.

Procedure

The video-based test stimuli and presentation setup were
the same as in Experiment 1. Verbal reports were collected
using a lapel wireless microphone set (Sennheiser EW
112-P G3, Wedemark, Germany), including a telemetry
radio transmitter fixed to the participant and a telemetry
radio receiver connected to a digital video camera. Before
completing the experimental tasks, participants were
instructed and trained on how to think aloud and provide
retrospective verbal reports. The instruction and training
protocol comprised Ericsson and Kirk’s (2001) adaption
of Ericsson and Simon’s (1993, pp. 375–379) original
protocol. The training session included instruction and
practice on thinking aloud and giving immediate retro-
spective verbal reports by solving a range of both generic
and domain-specific tasks (for an extended review, see
Eccles, 2012). The verbal report training protocol lasted
approximately 30 min.

At the end of the instruction phase, four warm-up
trials ensured that participants were familiar with the
experimental setting and the protocol procedure. Retros-
pective verbal reports were collected directly after each
trial. Testing sessions were carried out individually in a
quiet room and were completed in approximately 60 min.

Outcome Data Analysis

The measures of performance were the same as in
Experiment 1.
Verbal Report Data Analysis

The retrospective verbal reports for the three most discriminating trials per task condition (see Experiment 1) were transcribed and coded for each participant using the protocol analysis method described by Ericsson and Simon (1993). These were segmented using natural speech and other syntactical markers. Verbal reports were then categorically coded on two separate classification schemes, namely, types of cognition and interaction of perceptual-cognitive skills.

Cognitions. Participants’ verbal reports were categorized based on a structure adapted from Ericsson and Simon (1993) and further developed by Ward et al. (2003). This coding system included four major types of cognitive statement categories: (a) monitoring statements referred to all utterances recalling current actions or descriptions of current events; (b) evaluations were statements making some form of comparison, assessment, or appraisal of events that are situation, task, or context relevant; (c) predictions referred to statements anticipating or highlighting future or potential future events; and (d) planning statements were those referring to a potential decision on a course of action to anticipate an outcome event.

Interaction of Perceptual-Cognitive Skills. To analyze interactions between the different perceptual-cognitive skills, retrospective reports were classified based on a refined encoding/categorization system. This system was inductively developed to highlight statements made about key perceptual-cognitive skills (cf. Yang, 2003). These were classified according to three major concept categories: (a) postural cues reflected all statements referring to cue sources emanating from bodily form (e.g., “player shaped to pass long”); (b) pattern recognition reflected all statements representing relational information or an interaction between two or more players on the same team (e.g., “play switched across the back-four”); and (c) situational probabilities were those statements that referred to the likelihood of a particular event occurring in future (e.g., “striker in a good position to receive the ball”).

The reliability of the data was established using the same methods as in Experiment 1. For the cognitions analysis and interaction of perceptual-cognitive skills analysis, the intraobserver agreement was 93.2% and 94.4%, respectively, and for the interobserver reliability, 89.0% and 83.6%, respectively. These classification schemes were analyzed separately using a factorial three-way ANOVA with Group (skilled, less skilled) as the between-participant factor and Task Condition (far, near) and Type of Verbal Statement (monitoring, evaluation, prediction, planning; or postural cues, pattern recognition, situational probabilities) as within-participant factors. Greenhouse–Geisser procedures were used to correct for violations of the sphericity assumption. Significant main and interaction effects were followed up as in Experiment 1, and effect sizes were reported as partial eta squared ($\eta^2_p$). The alpha level was set at $p < .05$.

Results and Discussion

Outcome Data

Skilled players were more accurate than less skilled counterparts in anticipating the actions of opponents ($M = 69.3\%$, $SD = 7.8$ vs. $M = 34.9\%$, $SD = 9.0$), $F(1, 22) = 100.24$, $p < .001$, $\eta^2_p = .82$. Skilled players were more accurate compared with less skilled players in deciding on an appropriate tactical decision ($M = 82.8\%$, $SD = 8.9$ vs. $M = 50.5\%$, $SD = 6.2$), $F(1, 22) = 106.24$, $p < .001$, $\eta^2_p = .83$. Participants were more accurate in anticipating the actions of their opponents during the near task ($M = 61.5\%$, $SD = 19.8$) compared with the far task condition ($M = 44.7\%$, $SD = 25.7$), $F(1, 22) = 13.84$, $p < .001$, $\eta^2_p = .39$. No other main or interaction effects were significant; all $F \leq 1.07$, $p \geq .31$, $\eta^2_p \leq .05$. The skill- and task-specific differences are in agreement with those reported in Experiment 1.

Verbal Report Data

Cognitions. There was a significant main effect for group, $F(1, 22) = 43.16$, $p < .001$, $\eta^2_p = .66$. Skilled participants ($M = 7.21$, $SD = 1.51$) generated significantly more cognitive statements per trial compared with the less skilled group ($M = 4.71$, $SD = 1.21$). These results support our initial predictions suggesting that skilled players possess more complex domain- and task-specific memory representations when compared with less skilled players. A significant main effect for type of verbal statement was observed, $F(2,06, 45.27) = 269.90$, $p < .001$, $\eta^2_p = .93$. Bonferroni-corrected pairwise comparisons showed that participants generated significantly more monitoring statements ($M = 3.33$, $SD = 0.86$) than all other statement types. After monitoring statements, predictive statements ($M = 1.09$, $SD = 0.60$) were most frequently articulated. No differences were evident between the number of evaluations ($M = 0.67$, $SD = 0.62$) and planning statements ($M = 0.87$, $SD = 0.57$). Participants generated more verbal statements when viewing the near task ($M = 6.58$, $SD = 1.91$) compared with the far task situations ($M = 5.33$, $SD = 1.60$), $F(1, 22) = 14.61$, $p = .001$, $\eta^2_p = .40$. There was also a significant Task Condition x Type of Verbal Statement interaction effect, $F(1.91, 41.99) = 4.88$, $p = .013$, $\eta^2_p = .18$. Post hoc testing showed that participants verbalized significantly more predictive ($M = 1.39$, $SD = 0.64$ vs. $M = 0.79$, $SD = 0.38$) and planning statements ($M = 1.17$, $SD = 0.60$ vs. $M = 0.57$, $SD = 0.35$) during the near task in comparison with the far task condition.

A significant Group x Task Condition x Type of Verbal Statement interaction effect was observed, $F(1.91, 41.99) = 3.77$, $p = .033$, $\eta^2_p = .15$. Post hoc testing revealed that skilled players generated significantly more predictive and planning statements when interacting with the near compared with the far task. No differences were revealed for less skilled players in the type of verbal statements made across task conditions. These data are presented in Table 2. No other interaction effects were sig-
nificant; all \( F \leq 0.73, p \geq 0.40, \eta^2 \leq 0.03 \). These task-specific differences appear to be due to the more demanding and time-constrained situation presented by the near task. These constraints may have led skilled players to direct greater attention toward prediction rather than more reactive strategies, which may have stimulated richer and more complex retrieval processes from memory to plan and formulate an appropriate decision under pressure. On the other hand, less skilled players did not employ such advanced task-specific memory representations of the game (see McRobert, Ward, Eccles, & Williams, 2011; Ward, Suss, Eccles, Williams, & Harris, 2011).

**Interaction of Perceptual-Cognitive Skills.** These data are highlighted in Figure 3. There was a significant main effect for group, \( F(1, 22) = 37.85, p < .001, \eta^2 = .63 \). Skilled participants (\( M = 3.94, SD = 1.01 \)) generated significantly more perceptual-cognitive skills statements compared with the less skilled group (\( M = 2.39, SD = 1.06 \)). A significant main effect for type of verbal statement was observed, \( F(2, 44) = 22.36, p < .001, \eta^2 = .50 \). Bonferroni-corrected pairwise comparisons demonstrated that participants generated more postural cues (\( M = 1.33, SD = 0.70 \)) and situational probability statements (\( M = 1.11, SD = 0.61 \)) in comparison with pattern recognition statements (\( M = 0.68, SD = 0.58 \)). Participants also generated more verbal statements when viewing the near task (\( M = 3.58, SD = 0.80 \)) compared with the far task situations (\( M = 2.75, SD = 0.51 \)). \( F(1, 22) = 16.24, p = .001, \eta^2 = .43 \). There was a significant Task Condition × Type of Verbal Statement interaction effect, \( F(2, 44) = 36.31, p < .001, \eta^2 = .62 \). Post hoc testing showed that participants verbalized significantly more postural cues (\( M = 1.71, SD = 0.72 \) vs. \( M = 0.96, SD = 0.43 \)) and situational probability statements (\( M = 1.40, SD = 0.66 \) vs. \( M = 0.81, SD = 0.37 \)) during the near task compared with the far task condition. In contrast, more pattern recognition statements (\( M = 0.89, SD = 0.67 \) vs. \( M = 0.47, SD = 0.37 \)) were made in the far task in comparison with near task.

A significant Group × Task Condition × Type of Verbal Statement interaction effect was observed, \( F(2, 44) = 11.92, p < .001, \eta^2 = .35 \). Post hoc testing revealed that skilled players generated a greater number of statements relating to postural cues (\( M = 1.92, SD = 0.56 \) vs. \( M = 1.03, SD = 0.39 \)) and situational probabilities (\( M = 1.89, SD = 0.52 \) vs. \( M = 0.95, SD = 0.31 \)) during the near task compared with the far. During the far task, they made more pattern recognition statements (\( M = 1.44, SD = 0.41 \)) compared with the near task condition (\( M = 0.67, SD = 0.35 \)). Although less skilled players verbalized more postural cues–related statements (\( M = 1.50, SD = 0.63 \) vs. \( M = 0.89, SD = 0.48 \)) during the near task compared with far, no differences were evident for the number of pattern recognition (\( M = 0.28, SD = 0.28 \) vs. \( M = 0.33, SD = 0.32 \)) and situational probability statements (\( M = 0.92, SD = 0.35 \) vs. \( M = 0.67, SD = 0.38 \)) generated across the two tasks. No other interaction effects were significant; all \( F \leq 3.05, p \geq .06, \eta^2 \leq .12 \). These results reveal, for skilled participants in particular, the existence of a dynamic interaction between the different perceptual-cognitive skills during performance, with their relative importance varying significantly from one situation to the next depending on the unique constraints of the task.

Overall, the data suggest that skilled players activate more elaborate domain- and task-specific memory representations compared with their less skilled counterparts. The importance of different perceptual-cognitive skills varied as a function of the unique constraints imposed by the game. It appears that perceptual-cognitive expertise within a particular domain is accompanied by the development of a range of complex situational and task-specific knowledge representations and skills that guide the processing of pertinent information from the visual scene (Ericsson & Lehmann, 1996).

**General Discussion**

In this article, we examined the visual search and cognitive processes underpinning anticipation and decision making and how these differed as a function of skill level and a manipulation of task constraints. A prime focus was to examine whether and how the different perceptual-cognitive skills interact to facilitate successful anticipation and decision making. Based on previous research involving the analysis of visual search behaviors during film-based soccer simulations (e.g., Vaeyens et al., 2007b; Williams & Davids, 1998; Williams et al., 1994), we predicted that there would be systematic, skill-based

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**Table 2** Mean (SD) Frequency Scores per Trial for Type of Verbal Statement Across Groups and Task Conditions on the Cognitions Classification Scheme

<table>
<thead>
<tr>
<th>Type of Verbal Statement</th>
<th>Skilled Far Task</th>
<th>Skilled Near Task</th>
<th>Less Skilled Far Task</th>
<th>Less Skilled Near Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total statements</td>
<td>6.44 (1.25)</td>
<td>7.97 (1.40)</td>
<td>4.22 (1.04)</td>
<td>5.19 (1.21)</td>
</tr>
<tr>
<td>Monitoring</td>
<td>3.64 (0.73)</td>
<td>3.50 (1.00)</td>
<td>2.86 (0.73)</td>
<td>3.31 (0.82)</td>
</tr>
<tr>
<td>Evaluation</td>
<td>1.11 (0.57)</td>
<td>0.94 (0.69)</td>
<td>0.33 (0.32)</td>
<td>0.31 (0.41)</td>
</tr>
<tr>
<td>Prediction</td>
<td>0.94 (0.31)</td>
<td>1.86 (0.50)</td>
<td>0.64 (0.39)</td>
<td>0.92 (0.35)</td>
</tr>
<tr>
<td>Planning</td>
<td>0.75 (0.32)</td>
<td>1.67 (0.45)</td>
<td>0.39 (0.28)</td>
<td>0.67 (0.28)</td>
</tr>
</tbody>
</table>
differences in perceptual and cognitive processes as a function of the task constraints. We further expected that these perceptual-cognitive skills would reveal an interaction with each other during performance, with their relative use altering from one task situation to the other. The latter aim was particularly novel, marking an initial attempt to look at the relative interaction between perceptual-cognitive skills, rather than examining the importance of each of these skills in isolation from the others (Williams, 2009).

Skilled participants were more accurate than less skilled players at anticipating the actions of their opponents and deciding on an appropriate course of action. As expected, the data revealed a number of systematic differences in visual search behaviors between skilled and less skilled players across task constraints. Skilled players employed more fixations of shorter duration and toward a greater number of locations in the display (i.e., opponents, teammates, and areas of free space) when interacting with the far compared with the near task condition. On the other hand, when viewing the near task situations, skilled players typically employed fewer fixations of longer duration and mostly toward the player in possession of the ball. In contrast, less skilled players tended to be guilty of “ball watching” in both task conditions, spending longer periods of time fixating on the player in possession or the ball flight movement (cf. Williams & Davids, 1998; Williams et al., 1994).

Figure 3 — Mean (SD) frequency scores per trial for type of verbal statement across groups and task conditions on the interaction of perceptual-cognitive skills classification scheme for (a) skilled and (b) less skilled players.
In accordance with our initial predictions, skilled soccer players reported a greater number of cognition statements, suggesting that they were using sophisticated memory representations of the game, which are presumed to be crucial to help guide the search for, and effective processing of, task–specific information (see North et al., 2011; Roca et al., 2011; Ward et al., 2003). Moreover, skilled players engaged in more predictive and planning statements during the near task compared with the far task. Findings may reflect the more dynamic and severe temporal constraints of the near task condition compared with the far due to the closer distance between the ball/play and the participant. Our data suggest that skilled players are better than less skilled players at adapting their visual search and cognitive processing strategies in relation to the distinctive constraints of the task (Ericsson & Lehmann, 1996; Williams, Ford, Eccles, & Ward, 2011).

The different perceptual-cognitive skills were observed to interact during performance, with their importance varying as a function of the situational task constraint. In the far task, skilled players generated more thought processes related to the recognition of structure or patterns within evolving sequences of play. In the near task, these players made more statements about the postural orientation of opponents/teammates, followed by expectations as to what their opponents are likely to do in advance of the actual event (i.e., situational probabilities). On the other hand, less skilled players showed no differences in the number of statements related to pattern recognition and situational probabilities across tasks, with the only difference being the greater number of postural cues verbalized during the near task compared with the far. Our findings regarding the use of thought processes related to pattern recognition and postural cue usage appear to be confirmed by the visual search analyses in Experiment 1. Skilled participants fixated their gaze on more disparate areas of the display when viewing the whole field of play in the far task compared with the less skilled players. We speculate that this strategy may illustrate a tendency to identify familiarity and structural relations between features, such as the positions and/or movement patterns of players (North et al., 2011). In contrast, when the ball was closer to the player in the near task, they employed lower search rates generally focusing gaze on the player in possession, with the verbal report data showing they are picking up information from the postural orientation of that player ahead of a key event such as foot–ball contact.

No hypothesis was proposed as to the relative importance of situational probabilities across task conditions. We speculate that differences in the weight of situational probabilities for skilled players across the two tasks is related to changes in the cost–benefit ratio associated with accurate and inaccurate anticipation and decision-making judgments depending on the specificity of the task involved. For example, when the ball is in the other half of the field, there is probably very little cost as well as benefit in generating probabilities because the ball is far away and there is plenty of time available. In contrast, when the ball is nearer the goal, the benefit of assigning probabilities may increase because it may provide more time to formulate and select the most accurate response.

Findings have significant implications for the manner in which researchers and those involved in the training process try to capture and develop perceptual-cognitive skills in sport and other domains. The different perceptual-cognitive skills interacted in a dynamic and continuous manner during performance and as a function of the unique constraints of the task environment. Therefore, the value of measuring and/or training these skills in isolation may be questioned. In future, scientists and those involved in the training and development process should take into account the interaction of the different perceptual-cognitive skills when designing test protocols and training interventions. It may be that tasks should be developed in which the key perceptual-cognitive skills are trained together in the manner they would be used during actual performance.

In summary, skilled soccer players made more accurate anticipations and decisions compared with less skilled players, with these judgments being underpinned by quantitative differences in perceptual and cognitive processes that were unique to the constraints of the task. The different perceptual-cognitive skills interacted during performance, with the relative importance of each altering as a function of the game situation or task presented. Our approach provides an important contribution toward the development of more refined models of expertise and expert performance in sport.

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References


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