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Pattern recognition in soccer: Perceptions of skilled defenders and experienced coaches

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ABSTRACT

The ability to perceive and recognise patterns of play is important for performance in tasks with strict spatiotemporal constraints. Study aims were twofold: (i) to qualitatively investigate the mechanisms and processes underpinning how soccer players recognise patterns, (ii) to qualitatively investigate the importance of pattern recognition in competition and practice environments. Six skilled soccer central defenders and seven experienced soccer coaches were interviewed. A reflexive thematic analysis of the data identified six higher-order and twenty-two lower-order themes relating to pattern recognition and anticipation in competition and practice environments. The six higher order themes were: recognising danger and distance to ball, sources of information, experience, opposition team, organisation and communication, and development in practice environments. Participants shared that developing pattern recognition and game reading skill is crucial in creating effective practice environments that support the transfer of skills into competition. Providing central defenders with representative scenarios during practice is recommended to stimulate problem-solving and promote familiarity with patterns of play to underpin game reading and thus skilled performance.

1. Introduction

Perceptual-cognitive expertise is frequently described as the ability of an individual to process information from the environment and integrate with existing cognitive knowledge structures to produce an appropriate response (Marteniuk, 1976). A contrasting approach pertains to a more direct perception viewpoint on expertise (Gibson, 1979). Specifically, from this perspective, individuals adapt their movements to the interacting constraints of a performance environment by continuously perceiving information to regulate goal-directed actions and govern skilled behaviour (Seifert et al., 2013). Regardless of the theoretical lens adopted, researchers have long been interested in studying the perceptual-cognitive skills of expert performers to identify the underpinning mechanisms that contribute to their expertise (e.g., Abernethy & Russell, 1987; Hodges et al., 2021; Ward & Williams, 2003). The importance of perceptual-cognitive skills is magnified in dynamic and temporally constrained tasks such as medicine (Bertram et al., 2013), aviation (Russo et al., 2005) and sport (North et al., 2016; Roca et al., 2013), where performers must not only select appropriate responses, but do so under strict time pressure in the context of an ever-changing environment.

In this study, we adopt an indirect perception (i.e., information processing) approach to expert performance, highlighting the important interaction between cognition and action, as per the previous definition provided by Marteniuk (1976). In sports such as soccer, perceptual-cognitive expertise is demonstrated through the ability of skilled performers to think ahead and anticipate the actions of opposing players. In the present study we conceptualise anticipation in soccer through the term 'game reading', with this term used frequently by soccer coaches as an interchangeable term for anticipation (Williams & Jackson, 2019). Den Hartigh et al. (2018) investigated 'game reading' in youth soccer and found

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that players who were selected for a soccer school of a professional club were capable of processing and structuring game-related information to higher levels of cognitive complexity (Den Hartigh et al., 2018), when compared to their non-selected counterparts. Moreover, the selected players were better able to identify structured information on the field (e.g., positioning of teammates) and integrate relational information between players (Den Hartigh et al., 2018). Therefore, gaining an insight into *how* soccer players recognise patterns of play would provide further depth to our understanding of anticipation ('game reading') in soccer.

The ability to perceive and recognise patterns between features (i.e., players; Abernethy et al., 2005; North & Williams, 2019) is a perceptual-cognitive skill that has been proposed as important in 'reading the game' (cf. Williams et al., 2011). Following extended domain-specific practice, highly skilled performers are proposed to develop specialised cognitive knowledge structures which enable them to attend to the most important sources of information and disregard non- or less-relevant information (Ericsson & Kintsch, 1995; Ericsson et al., 1993; 2009). Together, this enables skilled performers to reduce the complexity of a display and encode information more efficiently. Information can then be evaluated and considered against previously encountered situations (North et al., 2011). Thus, experts are able to retrieve relevant task-specific information from their long-term working memory (Ericsson & Kintsch, 1995), which enables performers to anticipate quickly and accurately through the process of perceiving and recognising patterns.

An extensive body of laboratory-based experimental research has been conducted to extend our knowledge of pattern recognition (e.g., Allard et al., 1980), as well as understanding its underlying mechanisms (e.g., Williams et al., 2012). This includes attempts to understand the nature of information that underpins pattern recognition expertise employing techniques such as spatial occlusion methods (e.g., Williams et al., 2006), eye-movement data (e.g., van Maarseveen et al., 2018) and verbal protocol analysis (e.g., North et al., 2011). This body of research has provided evidence as to the importance of relative motion information between key players for pattern recognition. More specifically, when viewing offensive sequences of play, expert defenders rely on relations between centrally located attacking players as well as the player in possession of the ball to guide their familiarity judgements (e.g., North et al., 2017). However, there has been a notable lack of research that investigates how players and coaches perceive the importance, underpinning processes, and development of pattern recognition.

Researchers have presented evidence to understand the processes and mechanisms underpinning recognition and anticipation in soccer (North et al., 2009; North et al., 2011) and the relative importance of different perceptual-cognitive skills during anticipation (North et al., 2016). Using eye-movement analysis and verbal reports, North and colleagues (2009; 2011), found performance of skilled players on respective anticipation and recognition tasks to be positively correlated to a moderate extent. North et al. (2016) employed an anticipation paradigm in which skilled and less-skilled soccer players made anticipation judgments to stimuli in 'near' (ball in close proximity) and 'far' (ball far away) conditions that were presented in both film and point light display format to manipulate the availability of information from postural cues. When the ball was far away anticipation performance was unaffected by presentation mode, suggesting an important contribution of pattern recognition to anticipation. This quantitative research provides evidence as to link between pattern recognition and anticipation.

Qualitative investigations have the potential to provide a depth and richness of information that is not possible through traditional experimental protocols (Greenwood et al., 2014). This method of data collection provides an opportunity to ask skilled and experienced performers and coaches directly to better understand the construct under investigation. In recent years there has been a growth in researchers making use of qualitative research methods to investigate topic areas in skill acquisition and expert performance. For example, researchers have employed qualitative methods to understand practice design activities for visual exploratory activity in soccer (Eldridge et al., 2023), and factors affecting soccer coaching behaviour (Jewell et al., 2022). However, there remains a lack of work aimed at understanding player and coach perceptions of pattern recognition.

While not in the domain of soccer specifically, Carboch et al. (2023) conducted nine interviews with active or former professional tennis players (current coaches) exploring how players use anticipatory information sources for serving and returning in elite tennis. After conducting an open-coding analysis approach, the authors identified pattern recognition as a lower order theme. Participants reported that pattern recognition varies depending upon skill level and the authors highlighted the importance of players gathering information from various sources both before and during matches to support anticipation (Carboch et al., 2023), such as contextual information (Murphy et al., 2018). A rare example of using qualitative methods to investigate perceptual skill in soccer utilised interviews with professional players to understand contextual factors influencing decision-making (Levi & Jackson, 2018). Following an inductive thematic analysis, there were four dynamic (e.g., situational development of the match) and three static (e.g., external context of the match) themes that influence the ability of skilled soccer players to make confident, effective decisions during a match. From the perspective of skilled players, the ability to recognise and practice familiar patterns of upcoming opponents in representative training scenarios can help to support decision-making in competition (Levi & Jackson, 2018). Participants in the Levi and Jackson (2018) study also discussed how contextual factors (e.g., score, momentum, perceptions of performance) can influence the decisions made in competitive soccer matches. However, whilst these findings provide an initial and valuable insight to factors which affect decision-making, they do not offer in-depth analysis of how soccer players recognise patterns of play in competition, despite its apparent importance to expertise in soccer (Abernethy et al., 2005).

There is a paucity of research investigating what the players and coaches understand to be vital with regards to 'reading the game' and recognising patterns of play. This is somewhat surprising considering the volume of quantitative data amassed from previous experimental approaches. Moreover, and perhaps indicative of the general research area, there is a lack of research that has sought to garner the experiential knowledge of coaches, and not only their perceptions of what constitutes pattern recognition, but how they seek to develop this skill within practice activities. Therefore, our study aims were twofold: (i) to

qualitatively investigate the mechanisms and processes underpinning how soccer players recognise patterns, and (ii) to qualitatively investigate the importance of pattern recognition in competition and practice environments.

2. Methods

2.1. Philosophical assumptions

To understand the participants' perceptions of the importance of pattern recognition to 'game reading' in soccer, we used a qualitative approach that was underpinned by interpretivism and a relativist ontology. Relativism accepts that multiple subjective, but equally valid, realities of the world can exist (Sparkes & Smith, 2014). The approach used was framed epistemologically by constructionism, which considers knowledge as subjective and socially constructed (Smith & McGannon, 2018).

2.2. Participants

Six skilled soccer central defenders (M_{age} = 23 years, SD = 5.5; $M_{playing\ experience}$ = 14.1 years, SD = 4.1) and seven experienced soccer coaches (M_{age} = 43 years, SD = 10.5; $M_{coaching\ experience}$ = 23.1 years, SD = 3.6) were interviewed. Skilled central defenders were required to satisfy two criteria: to play semi-professional soccer or higher in the previous five years and classify themselves as a central defender (see Table 1 for details). Central defenders were recruited due to pattern recognition research in soccer typically asking players when viewing film-based stimuli to imagine themselves as a central defender (e.g., North et al., 2017) as this position allows defenders to see the whole game in front of them. The coaches were required to satisfy two main criteria: to possess a UEFA B qualification in football (soccer) coaching or higher and to have a minimum of 10 years of soccer coaching experience (see Table 2 for details). Using a criterion-based purposive sampling of defenders and coaches ensured that participants had appropriate experiences to discuss for the study, and the sample size offered sufficient experiences to address the aim of the study (Malterud et al., 2016). Ethical approval was granted from the lead author's institution and all participants provided written informed consent.

2.3. Interview guide

Semi-structured interviews were used to allow the emergence of unforeseen topics, with participants encouraged to share their knowledge and talk about personal experiences (see Smith & Sparkes, 2016). The interview guide comprised of five sections: soccer background, understanding of pattern recognition/game reading in soccer, use of pattern recognition/game reading in competition environments, pattern recognition/game reading in practice environments and the overall importance of pattern recognition/game reading in soccer. The lead author used commonly used coaching terms such as 'game reading' when conducting interviews with all participants.

Table 1: Participant characteristics of the six soccer central defenders that were interviewed.

Player	Gender	Age (y)	Experience (y)	Highest level played	Current level of play
P1	Male	19	12	UK Professional Men's Academy	UK Men's Semi-Professional
P2	Female	26	16	International Women's Soccer	UK Professional Women's Soccer
P3	Male	18	10	UK Professional Men's Academy	US College Soccer
P4	Female	32	20	International Women's Soccer	UK Professional Women's Soccer
P5	Male	25	17	UK Professional Men's Academy	UK Men's Semi-Professional
P6	Female	19	10	UK Professional Women's Soccer	UK Professional Women's Soccer

Notes: 'Highest level played' refers to the highest standard a player has competed. For example, if a player's highest competitive level of soccer played is 'International', this player has represented their national team in a competitive international match.

Table 2: Participant characteristics of the seven male soccer coaches that were interviewed.

Coach	Age (y)	Experience (y)	Highest level coached	Current level of coaching	Highest qualification
C1	38	21	UK Professional Men's Academy	UK Independent Men's Academy	UEFA A License
C2	49	31	UK Men's Semi-Professional	UK Men's Semi-Professional	UEFA A License
C3	40	23	UK Professional Women's Soccer	UK Professional Women's Soccer	UEFA A License
C4	38	23	UK Men's Semi-Professional	UK Men's Semi-Professional	UEFA B License
C5	36	20	UK Professional Men's Academy	UK Professional Men's Academy	UEFA A License
C6	65	22	UK Professional Men's Academy	UK Men's Semi-Professional	UEFA B License
C7	36	22	UK Professional Women's Soccer	UK Independent Men's Academy	UEFA A License

The interview guide was developed through: (i) quantitative findings in pattern recognition in soccer; (ii) the lead author's experiences of playing and coaching soccer (18 years playing experience and 8 years coaching experience); and (iii) assessing previous qualitative studies' interview guide approaches (e.g., Morris-Binelli et al., 2020; Pocock et al., 2020). Example questions posed to both soccer players and coaches were "are there any similar patterns of play in soccer that you see occur all the time?" and "in your own words, how important do you think pattern recognition is for a central defender in soccer?" The full interview guides used in this study are available as a supplementary file. A pilot interview was conducted with a central defender with 15 years of competitive playing experience. The interview was then reflected upon, with minor changes made, including removal of certain questions due to perceived repetition.

2.4. Data collection

All interviews were conducted by the lead author on an individual basis via Zoom (version: 5.4.9. 59931.0110). Participants were provided with a written information sheet, as well as a verbal description of the study before the interview. Furthermore, participants were made aware of the interview being recorded via an MP3 device as well as the confidentiality of their responses and their right to withdraw. Open-ended questions allowed for detailed descriptions of experiences (Smith & Caddick, 2012) and were used to build a discussion around the players' and coaches' knowledge and understanding of pattern recognition and game reading. Probe questions were used to encourage further articulation of points and build rapport (Smith & Caddick, 2012; Smith & Sparkes, 2016). Interviews ranged between 39 and 54 minutes (M = 46 minutes, SD = 5.3) and were audio-recorded on an MP3 device for data analysis.

2.5. Data analysis

Interviews were transcribed verbatim with grammatical changes made where necessary. To ensure anonymity, each participant was assigned an identifying label (i.e., coaches were labelled C1 to C7, and players labelled P1 to P6) to identify similarities and differences more easily (see Morris-Binelli et al., 2020). A reflexive thematic analysis approach was adopted, which allowed for identifying themes derived from the raw data (Braun & Clarke, 2019). This reflexive approach was centred around the lead author's role in knowledge production as well as the transparency and consistency of analytical decisions made during the analysis phase (Braun & Clarke, 2019). Towards the end of the coding process, a more collaborative approach was adopted to achieve greater depth when understanding the data. As part of this approach, the current investigation did not exclusively use either a deductive (structured, theory-driven approach) or inductive (little use of theory, framework, or pre-determined structure) approach. Instead, a pragmatic form of enquiry was selected, which applied both approaches (see Braun et al., 2016; Strafford et al., 2021). Understanding of previous literature related to pattern recognition in soccer, as well as the lead author's experiences of playing and coaching soccer, informed this pragmatic approach. To acknowledge and minimise any preconceived biases, the lead author took steps to explore alternative viewpoints during the interpretation stage of the analysis process. This involved discussing all codes and ideas with all co-authors. The current investigation followed the six phases of reflexive thematic analysis detailed by Braun and Clarke (2006; 2019). As part of this approach, a recursive rather than linear process was utilised for data analysis, as the lead author actively engaged with and immersed themselves in the data (Morris-Binelli et al., 2020).

The first stage of the analysis process followed a deductive approach where the lead author read each interview transcript multiple times to specifically identify language relating to pattern recognition and 'game reading'. Following this deductive approach, a strictly inductive approach was adopted to identify key themes from the raw data (Braun & Clarke, 2006). The third phase consisted of coding and collating units of text which were then reorganised and used to identify potential themes from the codes. Following this, the fourth phase involved initial themes being refined and sub-themes being formed which led to the creation of the 'thematic map'. In the fifth phase, the lead author conducted regular, meaningful reflections on the proposed themes. At this stage, the addition of a 'critical friend' (a lecturer in sport and exercise psychology) allowed for continual discussion and reflection on each theme and sub-theme to ensure the themes accurately reflected the data. Any coding differences that were identified were resolved through discussion and codes were altered if deemed appropriate (Strafford et al., 2021). The final phase involved writing up the analysis with the most relevant quotes from participants being selected to capture each high-order theme presented.

2.6. Methodological rigour

Two main processes were employed to ensure methodological rigour. First, four participants were randomly selected for member reflections (Tracy, 2010) which involved sending completed transcripts and an overview of the results to participants (Smith & McGannon, 2018). No changes were made to the transcripts or data analysis as a result of the member reflections. Nowell et al. (2017) emphasises how member checking can be used to enhance the credibility of the analysis process. Second, to enhance the confirmability of the research, an independent critical friend discussed the lead author's interpretations of the analysis. The critical friend was valuable during data analysis, providing constructive comments which enabled the lead author to reflect and defend their judgements concerning the proposed themes that were constructed from the data (Burke, 2016; Smith & McGannon, 2018).

3. Results

Prior to understanding perceptions of skilled defenders and experienced coaches on the importance of pattern recognition to anticipation ('game reading') in soccer competition and its development in practice environments, a logical starting point was to ask all participants to provide their definitions of the term 'game reading.' Coach 1 described 'game reading' as "thinking into the future… so identifying where the space is, where opposition players are, team members, where the ball is on the pitch." Similarly, Player 5 defined 'game reading' as "being able to adjust your position or your thought process to what you're seeing in front of you," with Player 3 describing 'game reading' as "reading the person, reading the situation and anticipating what's going to happen next."

The definitions provided by central defenders and coaches share a number of similarities. All quotes point to a player's ability to: (i) recognise emerging patterns of play before they unfold; (ii) identify relevant kinematic cues from opposition players; and (iii) continually adjust one's body position whilst visually exploring the environment to locate teammates, the ball, opposition players and empty space. In summary, based upon the perceptions of participants in this study, the key contributing factors to 'game reading' (i.e., anticipation) were kinematic cues, situational probabilities, visual information, and pattern recognition. While participants highlighted a number of perceptual-cognitive skills underpinning game reading in soccer, in the context of the present study, we were specifically interested in garnering their perceptions of the importance of pattern recognition to this process. To this end, a two-stage reflexive thematic analysis of the data resulted in the generation of twenty-two lower order themes and six higher-order themes (see Figure 1). The six higher-order themes are discussed and are supported with illustrative quotes from central defenders and coaches.

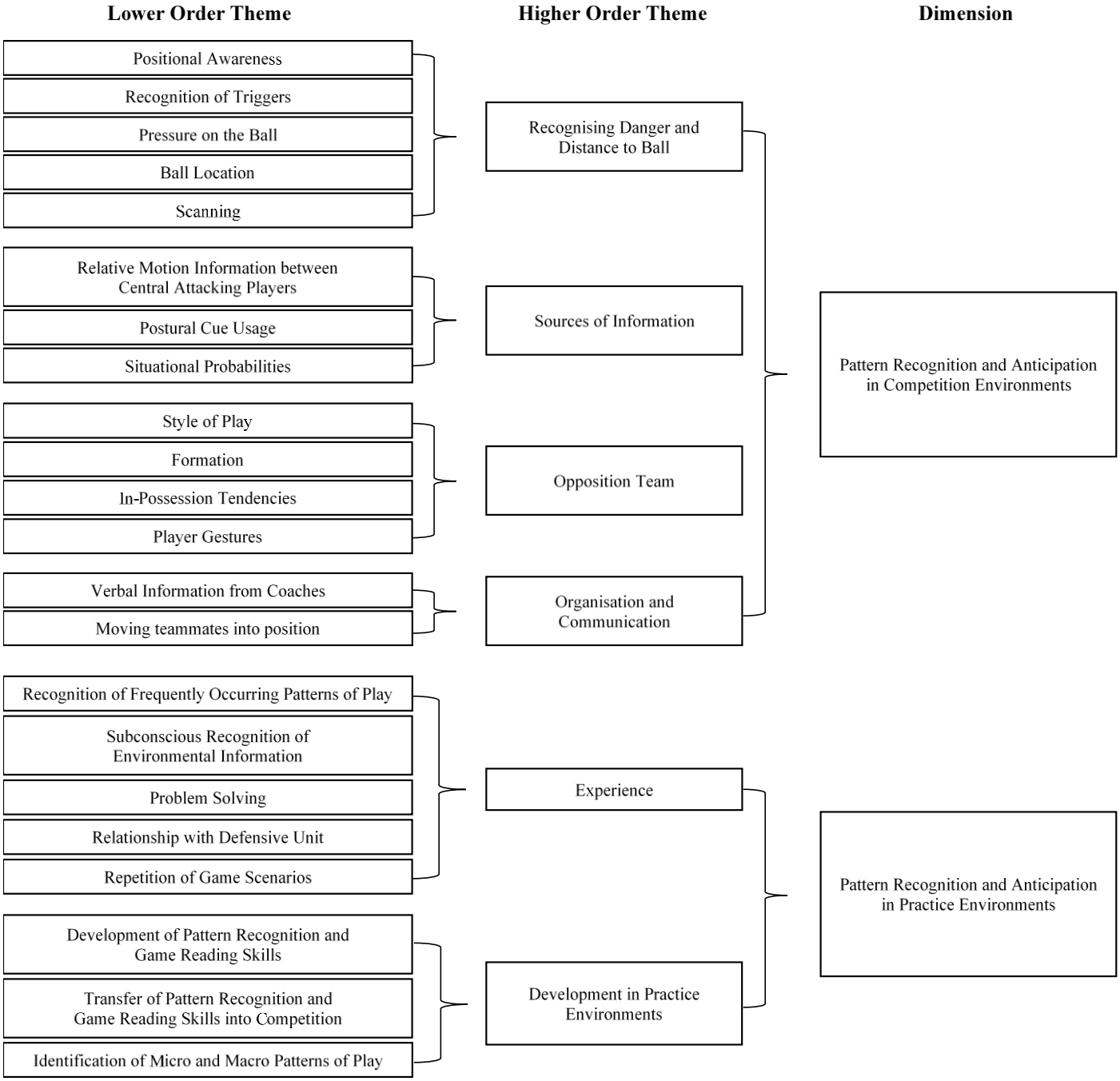

Figure 1: Thematic map of pattern recognition and anticipation in competition and practice from the perspectives of skilled soccer central defenders and experienced coaches.

3.1. Recognising danger and distance to ball

Both players and coaches referred to the importance of central defenders recognising dangerous situations and their distance to the ball which appears an important part of pattern recognition. Central defenders are required to frequently move their body and head to visually explore ('scan') their surrounding environment when out of possession to identify the movements of teammates and opposition players. Players and coaches also described how central defenders are required to have excellent 'positional awareness' and an ability to 'recognise triggers' (e.g., off the ball movements of central attacking players) which appeared heavily linked to 'ball location' and 'pressure on the ball'. Player 5 describes:

> "I'd want to be in a position so I can see the ball and the man I am marking. I want to be able to see both of those, and then across that I'm probably looking at my other centre back and my holding midfield player. Are they matched up in a good position of where the ball is going to be because even though the ball is quite far away from us it can travel quickly… as you get closer to the ball, then you become more interested in the ball rather than the runners and positioning around you" (P5).

Players explained how, when recognising emerging patterns of play, the ball's location combined with their positional understanding (identifying where they are standing on the pitch in relation to team-mates and opposition players), had a direct impact upon the prevention of dangerous situations. This is consistent with previous literature that identified how the position of the ball in relation to opposition players and the information that arises as a result of the interactive movements of team-mates, are critical structural information, linked to anticipation and recognition ability (see also Roca et al., 2013; North et al., 2016). Coach 7 explains:

> "… their [central defenders] ability to move forwards, backwards, sideways, just as the ball does, to get into positions, quickly… I think it comes down to those to understand if there's a trigger or pattern happening, but they've got to see that early" (C7).

Taken together, these findings suggest that during competitive performance, a central defender is required to continually evaluate their position whilst simultaneously identifying out of possession triggers to facilitate the recognition of structured patterns of play. Player 4 shared:

> "I'm looking at how deep the back line is. I'm looking at where the ball is, I'm looking at our shape. Are we narrow and compact? Are we cutting channel balls out, are we checking shoulders and picking up runners?" (P4).

This highlights how central defenders are visually scanning to pick out the most information-rich areas by checking their shoulders and processing each individual moment as the game unfolds in front of them. Research has detailed how players who visually explore their environments more effectively can perceive approaching opponents, identify teammates, and execute more appropriate passing options (e.g., Jordet et al., 2020). Player 4 further recalled an in-game situation where they recognised their active role in influencing the pattern of play:

> "If that midfielder hadn't been dragged out for us, we knew that they probably weren't going to try and break that line pass. So, they might have gone wide. So that's when the fullback knew that was their time, that was their trigger, and I would cover round, and the midfield would just kind of screen" (P4).

3.2. Sources of information

Both players and coaches highlighted the importance of a central defenders' ability to utilise various sources of information from the environment. More specifically, participants explained how central defenders draw upon postural cues of opposition players to predict likely upcoming situations. Players and coaches regularly acknowledged the importance of the 'relative motion information between central attacking players' be fundamental to successful pattern recognition and 'game reading'. Player 1 shared:

> "… the minute I saw that ball go there I'll see his head come up and his foot go back, he's going to play the ball… so, as I said, it was all about that, in each split second of movement, and where they were in analysing their striker's movement, or their winger's movement, it's just that really quick decision-making recognizing that pattern of play and where they're going to ultimately try to exploit" (P1).

This suggests there are various aspects of situational information that interact in a single phase of play. It appears that skilled central defenders can use their enhanced knowledge of game-specific event probabilities (Williams et al., 2005) and assign an abstraction hierarchy to select and recognise which information source is most pertinent in a given situation to inform their anticipatory judgements. Additionally, this links to the finding that when the ball is further away, the perception of structured patterns is most important, whereas when the ball is closer to the goal, recognition of an opponent's bodily movements provide the most important information for successful anticipation (Roca et al., 2013; North et al., 2016). One coach reported:

> "… looking at their centre forwards' forward runs and runs in behind, identifying key players, key strengths, recognising movements that they make…" (C3).

The above quote from coach 3 pertaining to the movement of central attacking players supports previous literature which has provided evidence to suggest that micro-relations between central attacking players are vital for successful pattern recognition for

both local and global (i.e., whole field) patterns (Hope et al., 2024; North et al., 2017; Williams et al., 2012).

3.3. Opposing team

Central defenders and coaches gave accounts of how the opposition team's formation, style of play, in-possession tendencies, and gestures from opposition players link to a player's ability to recognise patterns of play and 'read the game'. To exemplify, Player 3 said:

> "What are their tendencies? What are they looking to do? Are they looking to try and aim for the centre forward quite a lot? … So, I think the style of play and the patterns depends a lot on the team and where we are in the world … so that would depend on who you're playing" (P3).

Researchers have shown that soccer teams have behavioural patterns that shift throughout a competitive match where more common phases of play will occur, suggesting the importance of familiarity of the opposition team's in-possession tendencies (Gonçalves et al., 2019). This experiential knowledge from Player 3 reveals that opposition teams perform similar movement patterns based upon their playing philosophy and tactical shape. Coach 1 states:

> "I think it [pattern recognition] depends on who you're playing against. I think it depends on teams, you know, playing styles and the opposition that you're faced with and yeah, I mean, depends on team's formation, setup, philosophy, belief…" (C1).

This additional contextual information, through the analysis of future opposition and their preferred formation and style of play, may aid central defenders' ability to recognise structured sequences of play.

3.4. Organisation and communication

Players and coaches articulated how during competitive performance, a central defender's role involves organising team-mates into suitable positions and reacting to information from coaches. Participants explained the importance of central defenders using their voice to talk teammates through the game and into specific pitch locations to aid the recognition of emerging patterns to support 'game reading'. Player 5 explains:

> "… if I can stop the ball going into the centre forward by placing a man in front by calling one of my midfield players in front of that, that's me doing my job and doing my job better than if the ball going into the centre forward, and then me having to make a tackle…" (P5).

Evidence has suggested that as central defenders are positioned centrally on the pitch, this allows them to share beneficial task-specific information with team-mates (McLean et al., 2021). This may imply that regular use of verbal communication in the form of directing team-mates around the pitch as the ball is in transition may act as an anticipatory mechanism to prevent the ball from going into dangerous areas. Outside of soccer, previous literature has investigated the role of teammate communication in lacrosse (Riches et al., 2021) and beach volleyball (Klatt & Smeeton, 2020). Both studies provide evidence for the important role teammate communication plays in team sports to support decision making (Klatt & Smeeton, 2020) and anticipation (Riches et al., 2021). It is worth highlighting how a central defender's 'organisation and communication' should be considered relevant to pattern recognition and 'game reading' skills by organising team-mates into relevant positions. However, there may central defenders who are skilled at 'game reading', yet may lack leadership and organisation skills to communicate effectively with team-mates. Coaches can help develop the communication skills of defenders, as well as providing instructions to develop game reading skills. Coach 5 describes instructions provided to a central defender:

> "So, for example, I might say, 'open your body up so you can see that the wide player and you can see the ball" (C5).

Therefore, central defenders use frequent communication to organise players around them and receive verbal instructions from coaches, especially regarding areas of perceived weaknesses (Levi & Jackson, 2018). This example of precise, position-specific information provided to a central defender may be of value if a player struggles to recognise patterns of play. However, other than the work of Smith and Cushion (2006) who investigated the in-game behaviours of six professional soccer coaches and identified 'developing game understanding' as a key theme underpinning their behaviour, there is a lack of research conducted on identifying the in-game instructions provided to players by coaches.

3.5. Experience

Both coaches and central defenders articulated how experience of previous match and training situations appear to support central defenders in the recognition of frequently occurring patterns of play, the subconscious recognition of environmental information, the ability to problem solve and develop positional relationships with the defensive unit through repetition of game scenarios:

> "I don't actively think about myself recognising a pattern… I think a lot of it is subconscious if that makes sense because from my point of view, I've had a lot of football [soccer] by the time I was 18 at Academy level, I think I was capable of recognising patterns in games …so I think it was always at the back of my mind that I felt confident that I knew what to do when certain patterns were unfolding be it striker coming deep and attacking midfielder running in behind me" (P2).

Despite suggestions that pattern recognition may be a by-product of experience rather than a direct contributing characteristic to expert performance (North & Williams, 2019),

the quotes captured in this study indicate that skilled soccer central defenders consider previous experience an important aspect that directly contributes to their expertise. One coach explains:

> "A lot of centre backs who are a bit older might not be as quick but the experience on how they understand the game, they're starting to rehearse every scenario of the game that's going on in front of them and they get themselves into that position very early" (C4).

These findings can be considered in relation to the theory of long-term working memory (Ericson & Kintsch, 1995) in which skilled performers develop domain-specific knowledge structures through extended practice, and can 'chunk' (Chase & Simon, 1973) meaningful information together, allowing them to rapidly retrieve information in the long-term working memory to guide anticipatory judgments (Roca et al., 2011).

3.6. Development in practice environments

All central defenders and coaches acknowledged the importance of practice to develop pattern recognition and game reading skills through match realistic opposed practises, unopposed practices, and coaching through the game:

> "The game paced ones, the ones that were as realistic to games as possible, would benefit me the most… so, for me, it was doing stuff at match pace, whether it be even in a small-sided game or attack v defence was really beneficial because not only then could you get to recognise it [patterns], but you also get an understanding with your teammates…" (P2).

Central defenders expressed how game realistic practices are fundamental to developing pattern recognition skills. This is supported by previous literature that has emphasised the importance of representative practice environments with high levels of action fidelity and task functionality to promote the coupling of perception and action (Broadbent et al, 2015). Moreover, previous literature has stressed the importance of designing practice that involves repetition of monitoring 'off the ball' opposition offensive movements whilst subsequently engaging with ball location in connection with teammates positioning (Williams & Davids, 1998). Coach 4 shared:

> "… we can go and stand behind our defenders to see what they see, and we can really, we can talk to them, we can slow it down, we can give them more detail about their movements" (C4).

Coaches emphasises the benefits of 'coaching through the game'. For example, standing behind central defenders in practice activities and talking to them can help develop their ability to recognise patterns of play emerging in front of them, with coaches being able to direct their attention to the most information-rich areas.

Central defenders and coaches also commented on the use of small-sided games ('playing form activities', see Ford et al., 2010) compared with 11v11 games, macro patterns, micro patterns, and pattern recognition principles:

> "… it [pattern recognition] is challenging if you're training on a smaller pitch to really hit home pattern recognition, because the game the distances in a game compared to playing on perhaps like a small six a side pitch or an eight a side pitch is completely different" (P1).

Player 1's perspective is supported by research into decision-making in soccer which has identified how small-sided games fail to recreate the demands of a 11v11 match due to pitch size constraints resulting in players not performing frequent 11v11 actions such as long passes (O'Connor et al., 2017). On the contrary, previous research has found similarities between 11-vs-11 and small-sided games with one particular investigation finding that 7-vs-7 small-sided games were faster paced, yet representative of 11-vs-11 games with regards to the performance indicators measured (Bergkamp et al., 2020). More specifically, the study found 7-vs-7 small-sided games were representative of 11-vs-11 games with regards to actions performed, excluding aerial duels (Bergkamp et al., 2020). Coach 1 commented:

> "… you've got to solve the problem you've got in a small-sided game in a larger sided game. Ultimately, you've got to recognise patterns of play, and where the ball is going to travel to, etc." (C1).

Coach 1 challenges suggestions that small-sided games in practice may hinder a player's ability to recognise full-sided game patterns (Runswick et al., 2021; Hope et al., 2024). Coach 3 highlights how "The eleven a side game is just a whole passage of 1v1, 2v2, 3v3, 4v4, up to your five asides … trying to get players sometimes to recognise, yes, this is 11 v 11, but in this moment, for this next 5-seconds, it's a 2 v 1, it's a 3 v 2". By implication, soccer players and coaches have a collective understanding that pitch distances and player numbers influence pattern recognition, yet micro-patterns (i.e., 2v2) emerge during small-sided games that directly translate into moments in a full-sided game (macro pattern). In light of these findings, small-sided games may have important implications for the transfer of skills from practice to competition (Broadbent et al., 2015).

4. Discussion

The present study aimed to qualitatively investigate the mechanisms and processes underpinning how players recognise patterns in soccer, and to investigate the importance of pattern recognition in competition and practice environments. Participants were asked to provide their own definition of 'game reading' (anticipation) in soccer. Their understanding appeared to encompass abilities of pattern recognition and visual exploratory activity ('scanning') to support their ability to anticipate successfully. Research has highlighted the interaction of different perceptual-cognitive skills in various situations (Roca & Williams, 2016). Therefore, anticipation, which has been captured through

the more commonly used term in soccer 'game reading', may include what players are currently 'reading' (i.e., what is currently unfolding on the pitch) and may also be 'reading' what is likely to happen next. To summarise the key findings, both players and coaches explained the importance of central defenders recognising 'danger' (i.e., runs in behind the defence from central attacking players, or a lack of pressure on an opposing midfield player on the ball) which appeared linked to the distances between the defender and the ball. Based upon the experiences of both players and coaches, it is worth noting that effective 'scanning' behaviours can underpin this ability to recognise danger and distance to the ball.

Coaches and central defenders further emphasised the importance of experience and exposure to frequently occurring patterns of play which can develop anticipatory skills, positional awareness, and recognition of opposition team tendencies. As evidence, Player 5 shared "I don't think you'd do anything without having that pattern recognition, even making a tackle, you're recognising something, you're either recognising a striker's movement a weight of pass to come win the ball". These findings can be interpreted in relation to the theory of long-term working memory (Ericsson & Kintsch, 1995). Research has stated experts develop highly specialised knowledge structures through extended domain specific practice that enable them to identify structure and familiarity (North & Williams, 2019). Therefore, as shown by the experiential knowledge presented in this study, skilled central defenders may possess complex cognitive knowledge structures, which could have developed through repetition of extended, and specific practice. As a result, players may be able to rapidly retrieve task specific information from their long-term working memory (Ericsson & Kintsch, 1995) to anticipate future actions quickly and accurately, as well as perceive and recognise unfolding patterns of play.

Lastly, players and coaches frequently referred to how team dynamics influence pattern recognition and how the opposition team's tactical set-up (e.g., style of play, formation and in-possession tendencies) can provide valuable information to support the pattern recognition process. Participants highlighted how a central defender's role would involve frequently communicating to teammates to organise players into suitable positions on the pitch. These findings add to previous research which have highlighted the important role communication plays in team sports (Klatt & Smeeton, 2020; Riches et al., 2021), and how an opposition team's in-possession tendencies may influence a player's ability to recognise patterns of play. In light of these findings, there is a considerable lack of research that exists on understanding how team dynamics influence processes such as pattern recognition. We therefore encourage future research to investigate the role team dynamics (e.g., on-pitch verbal communication, opposition team tactical set-up and in-game coach instruction) play on soccer players' ability to recognise patterns of play.

4.1. Recommendations for practice design

Based on current findings, numerous implications are proposed for designing practice. Firstly, coaches are recommended to design practice activities that require central defenders to continually evaluate their defensive position. During these activities, coaches are encouraged to introduce game-related conditions that promote communication between central defenders and the rest of their defensive unit whilst ensuring players are continually mapping the location of the ball. Additionally, designing activities on a full-size pitch may facilitate the representativeness of practice which would enable central defenders to gain experience visually exploring their environment to locate 'off the ball' movements of opposition players and teammates. Techniques such as shadow coaching and questioning may aid the development of positional awareness, however coaches should avoid overloading players through constant instructions (i.e., 'over-coaching'), which has been reported to restrict guided discovery and may result in lower retention of skills, and performance breakdown under pressure (Ford et al., 2010; O'Connor et al., 2017). Secondly, small-sided games are encouraged to expose players to a high repetition of frequently occurring micro-patterns (i.e., 2v2, 3v3) that central defenders may encounter in dynamic instances in 11v11 matches. Thirdly, modified games (i.e., attack vs defence) in practice in which the opposition team replicates future oppositions' style of play and attacking movement patterns could provide central defenders with a priori knowledge to develop game reading and pattern recognition skills.

4.2. Future research directions

Despite the novelty of the current study interviewing both male and female skilled central defenders and experienced male coaches, no female soccer coaches were sampled. Previous literature has referred to a lack of female soccer coaches working within elite soccer, with only 7% of all soccer coaches being women (De Haan, 2020). Therefore, as women's soccer grows in popularity and the number of female coaches increase, future research should aim to prioritise the sampling of elite female soccer coaches. Furthermore, with the current study sampling both male and female soccer players there may be different pattern recognition requirements across male and female soccer players. Previous research has found differences in game structure across male and female soccer matches (Tenga et al., 2015), which could impact upon how players recognise patterns of play. However, more recently, research by O'Brien-Smith et al. (2020) has shown no differences in decision making between male and female youth soccer players suggesting pattern recognition processes may not differ. From the themes that emerged from the current study, no clear differences were found between skilled male and female soccer players in how pattern recognition processes were used to support skilled performance. As authors we are conscious of the bias towards the sampling of male participants in scientific research and the lack of research investigating female participants (Williams et al., 2020) and so there is a critical need to undertake more research with female participants (Elliott-Sale et al., 2021).

The current investigation relied upon the accuracy of participants' recall ability to disclose previous experiences, which must be considered when evaluating the findings (see Hopwood, 2015). Semi-structured interviews were adopted which only focus on the conscious pick up of visual information processed from the environment (see Morris-Binelli, 2020), failing to identify the sub-conscious information used during competition. However, some participants alluded to the subconscious processing of

information as a result of experience. In light of the findings, future investigations should aspire to better understand the transferability of pattern recognition and game reading skills from practice into competition. Enhancements made in virtual technology in soccer (see Wirth et al., 2018) and adopting more in-situ designs (see van Maarseveen et al., 2018) provide players with more representative viewing perspectives allowing for increased repetitions, variation in practice conditions, and rehearsal of scenarios that are challenging to reproduce in traditional practice (Gray, 2019). Whilst a representative viewing perspective allows for realistic information from opponents, there should also be consideration around interacting with team-mates (e.g., the defensive unit) when practising relevant scenarios (Janssen et al., 2023).

Previous research has suggested that practice in virtual reality environments may support one's ability to 'read the game' at a more unconscious level (Ferrer et al., 2020). An interesting approach therefore is to utilise the emerging technology of 360° video to present soccer central defenders with real-world video footage of emerging patterns of play from a first-person perspective presented through a head-mounted display. This display offers innovative alternatives to traditional video footage, which is typically presented from a third person perspective, and allows the player to scan their environment (Lindsey et al., 2023). This approach provides unique opportunities to not only assess soccer players decision-making ability (see Honer et al., 2023), but to understand the relative importance of pattern recognition to game reading processes from a first-person perspective which could have direct implications for developing practice design (Musculus et al., 2021). Therefore, future research should combine both qualitative and quantitative findings to gain a more comprehensive understanding of pattern recognition processes which can then be developed to support the transfer of these skills into competition.

5. Conclusion

To conclude, this study is one of the first to provide qualitative data concerning pattern recognition and game reading in soccer, based upon the experiential knowledge of skilled central defenders and experienced coaches. Skilled central defenders continually utilise multiple perceptual-cognitive skills to position themselves in optimal locations on the pitch to enable the recognition of emerging patterns of play. Coaches provided insights into current practice design and the importance of representative practice to develop pattern recognition processes. Therefore, coaches should make greater efforts to incorporate more representative game-like situations during practice to allow players to become familiar with pitch distances and the identification of macro and micro patterns. To summarise, skilled central defenders recognise danger by player to ball distances and interactive movements of opposition central attacking players, which is linked to experience, sources of information, positional awareness, and organisation. Therefore, the study provides a novel insight into how skilled central defenders read the game and perceive familiarity in emerging patterns of play to produce high levels of performance in dynamic sporting environments.

Conflict of Interest

The authors declare no conflict of interests.

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