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Cognitive processes underpinning soccer coaches' decision-making during competition

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Abstract

The ability of coaches to make effective decisions that can impact positively on a team's performance during competition is a fundamental skill in coaching, especially in fast, dynamic team sports such as soccer. Yet, there has been little research attention given to exploring the thought processes underpinning coaches' decision-making during soccer match-play. We used a think aloud protocol analysis to explore the cognitions of skilled and less-skilled soccer coaches who were required to watch and coach a team during representative video clips of a soccer match first half. At the end of the first half of the match, coaches were also asked to verbalise their thoughts of what they would do or say to the team at half-time. We further assessed the quality of decisions made at half-time. During first-half match-play, skilled coaches verbalised more thoughts related to performance and tactical evaluations, and the planning of actions than less-skilled coaches, who mostly monitored the ongoing game actions or events. Moreover, during half-time skilled coaches made more appropriate decisions which were underpinned by more relevant planning strategies aimed at improving team performance for the second half than less-skilled participants. Findings enhance our understanding of cognitive expertise in coaches' decision-making performance during competition.

Keywords: Expert performance; perceptual-cognitive skill; memory; verbal reports; coaching

Cognitive processes underpinning soccer coaches' decision-making during competition

In the second leg of the 2019 Champions League semi-final, Liverpool F.C. trailed F.C. Barcelona three goals to one at half-time. With his side needing three goals for victory, Jurgen Klopp decided to bring on Georgino Wijnaldum, a central midfielder, in place of the injured left-back Andy Robertson. Shortly after half-time, Wijnaldum scored twice in the space of two minutes to bring his team level, with Klopp's side ultimately claiming a 4-3 victory. Renowned as one of the world's best football coaches, Klopp's expert decision-making is likely to have been guided by immediately pertinent information (e.g., an injured left-back) and tactical information accrued over the course of the match (e.g., the effectiveness of his team's playing formation).

Perceptual-cognitive skill involves both the *identification* and *acquisition* of environmental information that can be integrated with existing domain-specific knowledge for effective decision-making (Williams & Jackson, 2019). Expert performers whose role it is to coordinate the actions of others, such as a chief of surgery, a business manager or a sports coach, are not only required to make instantaneous, quick decisions under time pressure but also more reflectively, by acquiring, analysing and integrating information accrued over an extended period of time to better inform future decisions (Johnson, 2006). In few domains is this ability to accrue information to guide decision-making more evident than in competitive soccer coaching (Harvey et al., 2015), where critical decisions are often made at half-time or even in the dying minutes of a match. However, while our understanding of how experts pick up and process current environmental information to inform time-constrained decision-making is relatively advanced (e.g., Belling et al., 2015; Roca et al., 2011), how information is acquired over a period of time to guide future decision-making has received much less research attention.

A wealth of research has now highlighted the perceptual-cognitive skills contributing to expert performance in dynamic environments (Williams & Jackson, 2019). Across a range of sports, experts have demonstrated superiority over less-skilled performers in their ability to detect familiarity in developing sequences or patterns of play (North et al., 2011; Williams et al., 2012), pick up advance visual cues (Murphy et al., 2016; Müller et al., 2006), and assign probabilities to potential event outcomes (Loffing & Hagemann, 2014; Ward et al., 2003). Moreover, the effective employment of these perceptual-cognitive skills is underpinned by more efficient visual search and cognitive processing (Roca & Williams, 2016). The ability to make sense of environmental information and use it for effective decision-making is therefore dependent on experts' cognitive processing strategies.

It is widely acknowledged that, through domain-specific practice (Ericsson et al., 1993), expert performers develop cognitive skills and strategies that allow them to process information more efficiently, thus circumventing normal information processing limitations of short-term memory (Ericsson & Kintsch, 1995; Ericsson & Lehmann, 1996). According to long-term working memory (LTWM) theory (Ericsson & Kintsch, 1995), domain-specific retrieval structures facilitate the rapid encoding and indexing of relevant information in long-term memory, as well as subsequent access to said information when required. This process of expanding working memory through extended domain-specific practice allows experts to engage in the type of extensive evaluation and planning processes that are inherently necessary in dynamic tasks (Harris et al., 2017; McPherson, 2000).

Researchers have examined the cognitive processes underpinning expert performance through the lens of verbal reports (e.g., Eccles, 2012; Roca et al., 2011; Whitehead et al., 2019). Though verbal reports of thoughts have been analysed in a variety of ways (e.g., Calmeiro & Tenenbaum, 2011; McPherson, 1999; Samson et al., 2017), the common observation is that experts' decision-making is characterised by a higher level of cognitive processing than that of their less-skilled counterparts. Specifically, and in line with Ericsson and Kintsch's (1995) LTWM theory, depending on the constraints of the task, experts have generally been shown to evaluate situations more fully, better predict future event outcomes, and engage in deeper planning than less-skilled performers (e.g., McRobert et al., 2011; Roca et al., 2011).

Retrospective verbal reports have often been employed to assess anticipation and decision-making in isolated instances (e.g., North et al., 2011; Roca et al., 2011), the rationale being that the time constraints of the situation are too severe for effective concurrent verbal reporting. However, when investigating the cognitive processes underpinning closed or continuous skills such as golf putting or cycling respectively, concurrent verbalisations of thinking are deemed more feasible (e.g., Calmeiro & Tenenbaum, 2011; Nicholls & Polman, 2008; Whitehead et al., 2019) due to the reduced risk of the report incompletely representing the participants' thought processes (Ericsson & Simon, 1993). Increasingly, researchers have attempted to recreate the competitive environment by collecting concurrent verbal reports throughout competitive performance (Larkin et al., 2018; Reeves et al., 2019; Samson et al., 2017; Whitehead et al., 2019). While both methods therefore appear to hold merit, when attempting to ascertain how information is accrued and later used for decision-making, as is the case in competitive soccer coaching for example, concurrent think aloud protocols would appear most suitable.

A few researchers have demonstrated an expert advantage in acquiring contextual information to aid anticipation over the course of a competitive encounter. McRobert et al. (2011) presented skilled and less-skilled cricket batters with video footage of bowls in two display conditions, one in which the order of the presented bowlers was randomised, and another in which all bowls from individual bowlers were presented in blocks of six. In addition to participants being more accurate when repeatedly anticipating the actions of the same opponent than when the viewing order was randomised, the skilled batters' gaze strategy became more efficient when they had a series of attempts over which to pick up the action tendencies of the bowler. Similarly, researchers (e.g., Farrow & Reid, 2012; Magnaguagno & Hossner, 2020) have demonstrated that experts can acquire and utilise knowledge of opponent action tendencies (e.g., likelihood of shooting to a particular corner of the goal) to enhance anticipation. For example, Mann et al. (2014) observed that, through repeated exposure to an opponent, skilled handball goalkeepers effectively acquire contextual knowledge of opponent action tendencies, which they then use to inform their anticipation judgments. These findings highlight the expert advantage in building a situational model into which relevant tactical knowledge can be integrated to inform subsequent decision-making (Ericsson & Kintsch, 1995).

Some of the only research investigating how expert performers acquire tactical knowledge to inform future decision-making during competition was conducted by McPherson and colleagues (McPherson, 1999; 2000; McPherson & Kernodle, 2007). Over a series of studies, skilled and less-skilled tennis players provided verbal reports of the thoughts they had during and between points. In contrast to the less-skilled participants, skilled tennis players were shown to integrate contextual information more thoroughly from previous points played (e.g., based on opponent action tendencies, strengths and weaknesses) with existing knowledge to inform future planning and decision-making. Similarly, through interviews with expert volleyball and tennis players, researchers have demonstrated that experts consider the build-up of tactical knowledge based on opponent action preferences, strengths and weaknesses to be an important factor in effective decision-making (Schläppi-Lienhard & Hossner, 2015; Vernon et al., 2018).

While our understanding of expert athletes' decision-making is well developed, we are less knowledgeable of how expert coaches make decisions. Researchers have examined coaches' decision-making during practice (e.g., Collins & Collins, 2015; Collins et al., 2016) and when making team and talent selection decisions (e.g., Fiander et al., 2021; Lath et al., 2021). However, few researchers have investigated their decision-making during competition, when the demands of the task require both immediate, quick and accurate decisions and the acquisition and integration of information over the course of a competitive encounter. In a rare example of research investigating decision-making during competition, Almeida et al. (2019) interviewed coaches to identify the information they used to make decisions and enhance the performance of their team. The researchers observed that coaches update tactical knowledge during matches based on factors such as individual player performances, opposition team strategy and external factors like pitch conditions. Harvey et al., (2015) used video-stimulated recall to interview three expert coaches from basketball, field hockey, and volleyball on decisions they had made in recent competitive encounters. The coaches highlighted the process of continuously updating tactical knowledge to inform decisions as being of greater importance for effective decision-making, compared with more immediate, time-constrained decisions. While these findings provide an initial exploratory description of coaches' decision-making during competition, the stimulated recall method may not evoke the cognitions that took place during the videotaped event (Wilcox & Trudel, 1998) and participants may present a degree of bias through, for example, the use of hindsight (Meier & Vogt, 2015). Thus, concurrent think aloud verbal reports, which are robust to such issues (Ericsson & Simon, 1993), would be a logical alternative to further understanding of the topic. Moreover, to inform applied recommendations for coach development, research investigating how cognitive processing over the course of a competitive encounter may influence future decision-making, e.g., at half-time, in skilled and less-skilled coaches is needed. This identification of skill-based differences can provide an indication of the cognitive strategies coach educators aim to cultivate in developing coaches (Ericsson & Smith, 1991; Ford et al., 2009).

The aim of this study was to examine the cognitive processes underpinning expert coaches' decision-making while coaching a team playing a competitive soccer match. To this end, skilled and less-skilled soccer coaches viewed a sequence of video clips representing one half of a competitive soccer match and were asked to continuously 'think aloud' while watching and coaching their respective team. Upon finishing watching these clips, participants were then asked to verbalise their thoughts of what they would do or say to the team at half-time. We further assessed the quality of decisions made at half-time. Based on Ericsson and Kintsch's (1995) LTWM theory and research highlighting the expert advantage in acquiring tactical information to build situational models (e.g., McPherson, 1999, 2000) that guide effective decision-making (e.g., Belling et al., 2015; Roca et al., 2011), we hypothesised that skilled coaches would make more evaluation, prediction, and planning statements than less-skilled coaches, who would primarily monitor the ongoing game actions or events. Furthermore, we expected that, during half-time, skilled soccer coaches would make more appropriate tactical decisions aimed at improving team performance for the second half than less-skilled participants. Finally, to provide an initial exploration of how information is acquired by coaches to inform future decision-making during a competitive encounter, we aimed to assess how the cognitive processes of skilled and less-skilled coaches differ during the first half of a simulated match compared with at half-time. Because of the exploratory nature of this aspect of the study, we did not propose specific hypotheses.

Methods

Participants

A total of 20 purposefully sampled British male soccer coaches participated in this study, 10 considered to be skilled (*M* age = 29.6 years, *SD* = 4.0) and the other 10 less skilled (*M* age = 23.3 years, *SD* = 5.5). Coaches were selected according to suggested criteria used in previous studies on expertise (cf. Ericsson et al., 1993; Nash & Sproule, 2011). Hence, at the time of the experiment, participants in the skilled group had a minimum of 10 years' experience coaching soccer (*M* = 11.8 years, *SD* = 3.0), held a Union of European Football Associations (UEFA) B (Level 3) (n = 4) or UEFA A (Level 4) (n = 6) coaching licence, and were working in youth academies of professional clubs in England. The less-skilled participants had a maximum of two years of experience coaching soccer (*M* = 1.9 years, *SD* = 0.4), held a UEFA C (Level 2) soccer coaching qualification or equivalent, and were employed by grassroots clubs. A priori power analysis was conducted using G*power (Faul et al., 2007). Due to our interest in the interaction between expertise level and cognitive processes, we based our calculations on the group by verbal statement type interaction effect size ($\eta_p^2 = .19$) reported by Shaw et al. (2021) who elicited verbal reports from skilled and less-skilled performers in a golf task with a set power of 0.95 for the within-between interaction and a moderate correlation amongst repeated measures (*r* = 0.3). The proposed total sample size required across the two groups was of at least *n* = 16. Ethical approval was obtained from the lead institution's research ethics committee and research was conducted in accordance with the guidelines of this committee. All participants provided written informed consent prior to participation.

Experimental task

Participants were presented with a sequence of representative video clips of a soccer match first half. The footage offered a viewing perspective from the dugout and was part of an under-19 elite soccer match that participants had never seen prior to taking part in the experiment (see Figure 1). The video stimuli comprised of five video clips lasting between 3 to 5 min each (*M* = 4.01 min, *SD* = 1.17) and were played in chronological order to provide a realistic representation of the match context. Participants were presented with the first 5 min of the match to help them familiarise with the game, the last 5 min before half-time to offer them a clear viewpoint of how the first half ended, and another three clips in between showing key moments of the game containing goals and goal scoring opportunities (e.g., the team in control of the game and eventually going 0-1 down at the halfway mark of the first half). According to Williams and Ford (2008), researchers studying expertise should put effort into identifying and isolating the critical periods within a task (e.g., key moments within a soccer match) where the greatest expertise differences may be displayed in order to enhance our understanding of the processes underpinning superior performance. Additionally, research has also demonstrated that attempting to collect concurrent verbalisations of thinking for a long period of time (e.g., a continuous full half or 90-min soccer game) is mentally draining and challenging for participants (Reeves et al., 2019).

Figure 1. Example of a frame extracted from the soccer video test stimuli.

Apparatus and procedure

Data collection was carried out remotely via a video conferencing platform (Zoom Video Communications, CA, USA). Participants viewed footage on a standard laptop or desktop computer and video sequences were uploaded to a video-sharing platform (YouTube, CA, USA) via a private link to which participants only had access when starting the experiment. All participants were required to watch and coach the same team in the orange kit with the goal of helping them win the match. In order to elicit coaches' thought processes during the match, participants were instructed to verbalise their thoughts continuously as they were experienced during task performance (i.e., "please think aloud and try to say out loud anything that comes into your mind whilst you watch and coach your respective team"). If they were silent for any length of time during the task, they were asked to resume thinking aloud. At the end of the first half of the match, coaches were also asked to verbalise their thoughts about what they would do or say to the team at half-time.

Prior to testing, participants received standardised training and instructions on how to provide concurrent, think aloud verbal reports (i.e., level 1 and/or 2 verbalisations) using Ericsson and Kirk’s (2001) adaptation of Ericsson and Simon’s (1993) original protocol. Training consisted of instruction and practice on how to give concurrent and retrospective verbal reports by solving a series of generic (i.e., alphabet exercises and counting the number of dots on a page) and sport-specific tasks (i.e., two warm-up trials from a different soccer match to the one used in the experimental stimuli) for approximately 30 min. Feedback was given to participants during training to ensure that their verbal reports were consistent with the instructions (for an extended review, see Eccles, 2012). During verbal reports training and testing, the researcher and participant switched off their video cameras to minimise intrusion and decrease self-consciousness for verbalisations from the participant. Participants’ verbal reports were recorded electronically through the video conferencing platform recoding option. Each individual test session was completed within 60 min.

Data analysis

Decision-making accuracy data.

To obtain an indication of the quality of the decisions that coaches are making at half-time, a panel of three independent expert, full-time youth soccer coaches (holding a minimum of the UEFA A coaching licence) from an English Premier League club determined all the relevant tactical options that might be taken with the aim to improve team performance for the second half (c.f., Murphy et al., 2019). Expert coaches derived their answers after repeatedly watching and analysing the sequence of match video clips used in the experimental task. All tactical decisions for which agreement was obtained across the expert panel were included as options against which participants’ performance would be scored. In total, seven appropriate tactical options were listed (see Table 1). Each participant was awarded a point for each tactical decision verbalised during half-time that corresponded to any of those agreed by the expert panel. The scores obtained for the coaches' decision accuracy at half-time were compared between the skilled- and less-skilled groups using an independent *t*-test.

Table 1. Pool of relevant tactical options, agreed by the expert panel, against which participants' decisions made at half-time would be scored

	Tactical options
Option 1	Find our wingers / central attacking midfielder between the lines more often
Option 2	Improve our use of the ball and movement off the ball when wingers or attacking midfielders have received between the lines
Option 3	Reduce number of straight clipped through balls
Option 4	Defensive line needs to be braver in holding their line when we turn over possession
Option 5	Cut out unforced technical errors resulting in cheap counterattacks for opposition
Option 6	Occupy the box with more bodies after penetrating the last line
Option 7	Improve the quality of the final pass / cross in the final third

Verbal report data.

Participants' verbal reports were transcribed verbatim and segmented using natural speech and other syntactical markers. An initial task analysis was undertaken to identify the types of thoughts verbalised by coaches during the experimental trials (e.g., see Eccles & Arsal, 2017). Based on this analysis, we adapted Ericsson and Simon's

(1993) cognitive category framework to better reflect the specificity of the task, and thus allow a more complete skill-based comparison between groups. The final coding system included five types of cognitive statement categories (see Table 2). The first and second authors analysed the verbal reports and conducted inter-observer agreements and further analysis to determine intra-observer reliability three weeks later. The inter-observer reliability for the verbal reports was 85.4% and for first and second authors intra-observer agreements were 94.5% and 92.0%, respectively (see Thomas et al., 2015 for procedures used to determine intra- and inter-observer reliability).

Verbal report data for: i) video sequences of first-half match-play, and ii) what coaches would do or say to the team at half-time were analysed separately using 2 x 5 (Group [skilled, less-skilled] x Verbal Statement Type [monitoring, performance evaluation, tactical evaluation, prediction, planning]) ANOVAs. Finally, pairwise comparisons were conducted to investigate differences between groups in the type of statement made.

The Greenhouse-Geisser correction was employed in the case of violations of Mauchly's test of sphericity. Effect sizes are reported using partial eta squared (η_p^2) in all instances and Cohen's *d* for comparisons between two means. The alpha level of statistical significance for all tests was set at .05 with Bonferroni corrections applied to control for familywise error where multiple *t*-test comparisons were conducted.

Table 2. Themes used to code verbalisations

	Description *‘Example from this study’*
Monitoring	Eliciting descriptions of current game actions or events *‘Fullback looking to switch the play’*
Performance evaluation	Making some form of relevant individual or collective performance comparison, assessment, or appraisal *‘Should have received on the back foot to play forward’*
Tactical evaluation	Making some form of relevant tactical or strategic comparison, assessment, or appraisal *‘Not happy with the large distances between units and lines of press’*
Prediction	Anticipating or highlighting possible future events *‘Number 10 looks the most likely player to try to penetrate and break the defensive line’*
Planning	Potential decisions aimed to improve individual or collective performance in a future situation *‘Needing to circulate the ball more at the back to draw the opposition out and disorganise them’*

Results

Decision-making accuracy data

There was a significant skilled-based difference for the quality of decisions made by coaches at half-time, $t(18) = 6.57$, $p < .001$, $d = 2.93$. The skilled group ($M = 3.60$ appropriate decisions, $SD = 0.97$) made more appropriate tactical decisions aimed at improving team performance for the second half when compared with their less-skilled counterparts ($M = 1.20$ appropriate decisions, $SD = 0.63$).

Verbal report data

During first-half match-play.

The total number of verbalisations significantly differed between the skilled (M = 110.4 statements, SD = 22.9) and less-skilled coaching groups (M = 144.0 statements, SD = 35.6), $t(18) = -2.51$, $p < .05$, $d = 1.12$. Therefore, to allow for more accurate, relative comparisons between groups, the frequency scores for each category were subsequently normalised into percentage data and used in all subsequent analysis.

Figure 2 presents the mean percentage for statement type verbalised by skilled and less-skilled coaches during first-half match-play. A significant main effect for type of verbal statement was observed, $F(2.19, 39.47) = 122.83$, $p < .001$, $\eta_p^2 = .87$. Bonferroni pairwise comparisons showed that participants made a significantly greater proportion of monitoring statements (M = 46.4 %, SD = 27.4) followed by performance evaluations (M = 29.4 %, SD = 11.7), tactical evaluations (M = 16.3 %, SD = 13.2), planning (M = 6.8 %, SD = 6.6), and predictions (M = 1.1 %, SD = 1.5) (all p's < .01).

There was a significant Group × Statement Type interaction, $F(2.19, 39.47) = 78.98$, $p < .001$, $\eta_p^2 = .81$. Follow-up t-tests revealed that during first-half match-play, skilled coaches verbalised a significantly greater percentage of thoughts related to performance (M = 37.7 %, SD = 8.7 vs. M = 21.2 %, SD = 7.9, $p < .001$, $d = 1.99$) and tactical evaluations (M = 27.7 %, SD = 8.1 vs. M = 4.9 %, SD = 3.7, $p < .001$, $d = 3.62$), and the planning of actions (M = 11.6 %, SD = 6.1 vs. M = 1.9 %, SD = 1.8, $p = .001$, $d = 2.16$) than less-skilled coaches. On the other hand, less-skilled coaches mostly monitored the ongoing game actions or events when compared with their skilled counterparts (M = 71.7 %, SD = 9.0 vs. M = 21.2 %, SD = 9.7, $p < .001$, $d = 5.40$) (see Figure 2).

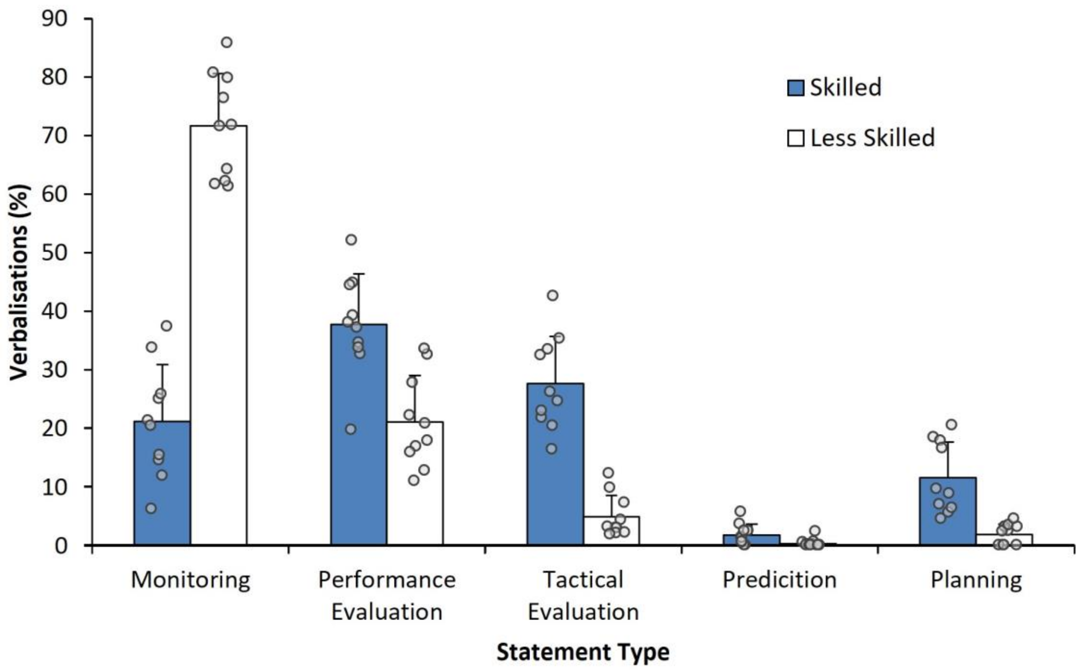

Figure 2. Mean % for statement type (with SD bars and individual data points) verbalised by skilled and less-skilled coaches during first-half match-play.

During half-time talk.

Figure 3 presents the mean percentage for statement type verbalised by skilled and less-skilled coaches during half-time. There was a significant main effect for type of verbal statement, $F(2.26, 40.73) = 23.03$, $p < .001$, $\eta_p^2 = .56$. Pairwise comparisons showed that participants made a significantly greater proportion of planning (*M* = 40.2 %, *SD* = 19.5), performance (*M* = 28.7 %, *SD* = 23.4) and tactical evaluations (*M* = 21.8 %, *SD* = 13.7) than monitoring (*M* = 5.2 %, *SD* = 11.6) and prediction statements (*M* = 4.1 %, *SD* = 5.7). Also, a higher proportion of planning statements were verbalised in comparison with tactical evaluation statements (all *p's* < .05).

A significant Group × Statement Type interaction was observed, $F(2.26, 40.73) = 11.39$, $p < .001$, $\eta_p^2 = .39$. Follow-up *t*-tests revealed that, during half-time, skilled soccer coaches generated a greater proportion of planning strategies aimed to improve team performance for the second half than less-skilled participants (*M* = 56.3 %, *SD* =

13.0 vs. *M* = 24.1 %, *SD* = 7.5, $p < .001$, *d* = 3.03). Less-skilled coaches, on the other hand, verbalised a significantly greater percentage of performance evaluations in comparison with their skilled counterparts (*M* = 42.1 %, *SD* = 24.0 vs. *M* = 15.3 %, *SD* = 13.6, $p < .01$, *d* = 1.37) (see Figure 3).

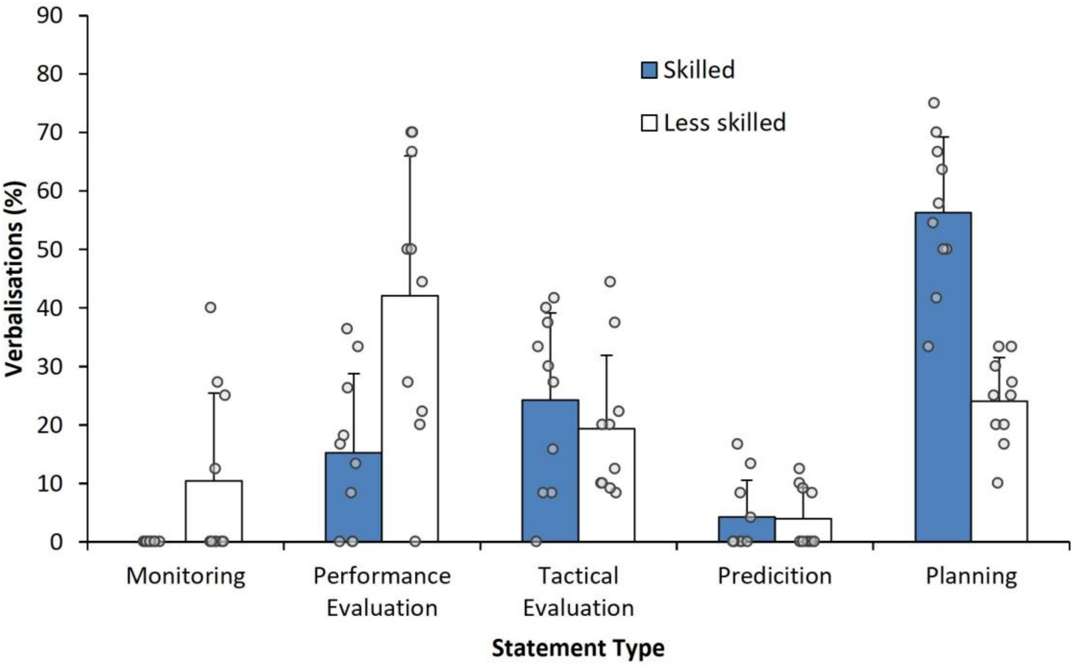

Figure 3. Mean % for statement type (with SD bars and individual data points) verbalised by skilled and less-skilled coaches during half-time.

Discussion

This study aimed to explore the thought processes underpinning coaches' decision-making during competition. We used a think aloud protocol analysis to explore the cognitions of skilled and less-skilled soccer coaches as they viewed and coached a soccer team during a sequence of videos clips representing the first half of a competitive match. At half-time, participants were then asked to verbalise their thoughts of what they would do or say to the team and the quality of the decisions made were also assessed. Most studies on expertise have investigated the cognitive processes underpinning immediate performance typically employed by athletes (Calmeiro & Tenenbaum, 2011; Murphy et al., 2016; Roca et al., 2011). To the best of our knowledge, this is one of the first attempts in the coaching expertise literature to examine the cognitive processes underlying coaches' decision-making during performance and how information is acquired and used to subsequently guide decision-making.

In line with our first hypothesis, skilled soccer coaches selected three times more appropriate tactical decisions during half-time aimed to improve team performance for the second half when compared with their less-skilled counterparts. Also as predicted, the results revealed that between-group differences in decision-making performance were underpinned by quantitative and qualitative differences in cognitive thought processes. The cognitive processes of skilled coaches involved a greater percentage of thoughts related to performance and tactical evaluations as well as the planning of actions when compared with less-skilled coaches. In contrast, less-skilled coaches mostly monitored the ongoing game actions or events when compared with their skilled counterparts. These findings are in line with previous research on cognitive processes underlying expert athletes' decision-making in isolated, time-constrained instances (e.g., North et al., 2011; Roca et al., 2011; 2013a), providing support for the notion that expert coaches' decision-making is characterised by a higher level of cognitive processing than that of their less-skilled counterparts. Findings suggest that skilled coaches employ more sophisticated memory representations of the game to produce effective decisions. Moreover, these findings might be explained by the expert coaches' superior domain-specific memory representations that are essential to help guide the search for and efficient processing of task-relevant information, including knowledge of the opposition’s strengths and weaknesses and contextual evaluation of the game’s ongoing tactical or strategic circumstances, (Magnaguagno & Hossner, 2020; Murphy et al., 2016; Williams & Jackson, 2019). Our findings can be interpreted as evidence supporting the LTWM theory (Ericsson & Kintsch, 1995) in which skilled coaches, when facing similar events from past experiences (acquired through extensive deliberate practice), are able to rapidly access the related task-relevant information stored in long-term memory through retrieval cues, allowing them to engage in advanced planning, prediction, and evaluation of current match performance events and respond to these situations more effectively. Moreover, building on previous research (Almeida et al., 2019; Harvey et al., 2015; McPherson, 1999; 2000; McPherson & Kernodle, 2007), our findings suggest that skilled coaches accrue and integrate task-relevant information during competitive encounters through evaluation of events and player performances to build situational models that guide effective decision-making.

During half-time, and in line with our initial hypotheses, skilled soccer coaches verbalised a greater proportion of relevant planning strategies aimed to improve team performance for the second half than less-skilled participants. On the other hand, less-skilled coaches generated a significantly higher percentage of performance evaluations in comparison with their skilled counterparts. When comparing the cognitive processing of the two groups during the first half of the match with half-time, skilled coaches’ strategy of attending to, and processing more task-relevant information during competition appears to give them the advantage to build richer situational models (e.g., McPherson, 1999, 2000) that guide the planning of more appropriate tactical decisions at half-time (to enhance the team’s performance for the second half). In contrast, less-skilled coaches’ lack the cognitive strategies required to thoroughly evaluate domain-specific information as it arises, thus hindering the efficiency of the decision-making process. To exemplify, skilled coaches more fully evaluated events as they arose during the first-half, while less-skilled coaches were constrained to merely monitoring the ongoing actions and events. In turn, the information that skilled coaches gleaned from their evaluations of the first half yielded more relevant planning strategies at half-time, whereas less-skilled coaches spent half-time largely engaging in evaluation of previously monitored events. Overall, our data suggests that, in domains like soccer coaching, where information is picked up and processed relative to current knowledge to inform decision-making, skilled coaches appear to evaluate various aspects of the match more fully (i.e., performance and tactical events) to inform more effective decision-making at half-time.

This study is not without limitations. From a theoretical standpoint, while we interpret our findings through Ericsson and Kintsch's (1995) LTWM theory, some aspects of the theory have been disputed (e.g., Gobet et al., 2000a, 2000b, Vicente & Wang, 1998). For example, Gobet (2000a, 2000b) suggests the theory lacks specificity and detail in its explanation of retrieval structures, which are integral to our interpretations of the findings, and highlights the resultant difficulty in forming testable hypotheses from theory. Our findings nevertheless align with previous research (e.g,, McRobert et al., 2011; Roca et al., 2011) supporting, and the broad principles of, LTWM Theory (Ericsson & Kintsch, 1995). In terms of the scope of the study findings, we have provided a mere snapshot of the processes underpinning expert coaches' decision-making, highlighting that tactical knowledge, in some form, is acquired during competition to inform future decisions. However, in the real world, numerous contextual and external factors are likely to influence decision-making (Levi & Jackson, 2018). While we have controlled for or not considered these factors in this initial investigation, future research should aim to ascertain how such factors influence the cognitive processes underpinning coaches' decision-making during competition.

The findings of this study are important for aiding the development of less-skilled coaches' decision-making skills. Results are in accordance with previous research findings on perceptual-cognitive expertise in sport (for a review, see Williams & Jackson, 2019) suggesting that the lesser-skilled coaches miss out on important tactical and strategic information due to mostly monitoring the ongoing game actions or events and focusing on the area where the ball is (e.g., Roca et al., 2011, 2013b; Ward et al., 2003). The complexity and uncertainty in soccer increases the difficulty of the decision-making process, emphasising the need for coaches to possess highly effective and efficient perceptual-cognitive skills (Williams & Jackson, 2019). Therefore, it is important that novice coaches are sufficiently exposed to situations where the process of continuously evaluating and updating tactical knowledge to inform decisions is key for effective decision-making (Harvey et al., 2015). This may include on-field training but also off-field game-simulation training opportunities in which the developing coach is encouraged to search for relevant information sources and provided with relevant feedback as to the effectiveness of their decisions (akin to how perceptual-cognitive skills have been trained in athletes and sports officials, e.g., Abernethy et al., 2012; Kittel et al., 2021).

To our knowledge, this is one of the first studies to demonstrate that skilled coaches use information picked up over the course of a competitive encounter (i.e., throughout key sections from one half of a match) to guide their decision-making. However, it is likely that, in domains like sports coaching, expert performers accrue information over much longer periods of time to make effective decisions based on, for example, player/team performance during training, player and opponent fatigue levels, positioning in league table, etc. In future, researchers should therefore attempt to measure coaches' cognitive processes across sequential competitive encounters within matches and more prolonged periods of time (e.g., over a series of competitive matches) to examine how decision-making is acquired and developed over time. Additionally, collecting coaches' verbal reports between matches can advance our understanding of the reflective processes that they may go through to build up their knowledge base to inform decision-making (e.g., Collins et al., 2016). Equally, given how much of the coaching process occurs outside of competition, there would be value in investigating the cognitive processes underpinning expert coaches' decision-making during other parts of their role, e.g., during training or while engaging in talent identification procedures (Ford et al., 2009).

In this paper we have demonstrated that skill-based differences in coaches' decision-making during competition are underpinned by differences in cognitive thought processes. Skilled coaches showed a greater ability to pick-up and evaluate match-related performance and tactical information during (first half) competition to inform and plan more appropriate strategic decisions at half-time. In contrast, less-skilled participants mostly monitored the ongoing game actions when compared with their skilled counterparts. Moreover, skilled coaches engaged in more relevant planning strategies aimed at improving team performance for the second half. Findings reveal the cognitive processes that mediate coaches' expert decision-making performance during competition in the sport of soccer and may contribute to further developing theoretical accounts in the field.

Authors’ Declarations

The authors declare that there are no personal or financial conflicts of interest regarding the research in this article. The authors declare that they conducted the research reported in this article in accordance with the Ethical Principles of the Journal of Expertise. The authors declare that they are not able to make the dataset publicly available but are able to provide it upon request.

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