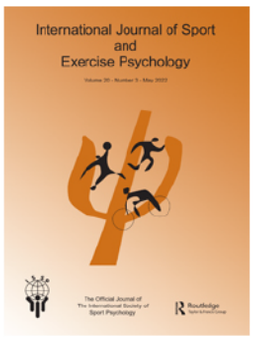

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Muscular collision chess: a qualitative exploration of the role and development of cognition, understanding and knowledge in elite-level decision making

Rosie Collins [a,b], Dave Collins [b,c] and Howie J. Carson [c]

[a]Faculty of Health and Life Sciences, Oxford Brookes University, Oxford, UK; [b]Grey Matters Performance Ltd., London, UK; [c]Institute for Sport, Physical Education and Health Sciences, Moray House School of Education and Sport, The University of Edinburgh, Edingburgh, UK

ABSTRACT

Decision making (DM) is a crucial part of team invasion games. The role of context and how this drives both initial DM and primes in-action planning and execution, termed contextual priors, has been investigated. Findings suggest a significant role for cognition, which appears to run contrary to some of the suggestions made by an ecological dynamics approach. Wishing to clarify this situation for coaches and psychologists, this research explores the experience of nine top-tier key decision makers in rugby union, using an interview approach. Results showed a wide range of context-based information considered by players during the DM process. Furthermore, this information acted to prime subsequent attention and in-action thinking. Finally, this research sought to understand if, and therefore how, DM could be taught, developed and primed by players and coaches. Our data are supportive of a more cognitively focused approach to developing DM, although our data do not dismiss a role for direct perception in optimising performance. Implications for practice are discussed.

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Cognitive psychology; contextual priors; ecological dynamics; planning; rugby

Within elite sport, accurate anticipation of "what happens next" is an important factor for success (Williams et al., in press). Terms such as "game intelligence", or "skilled anticipation", are often used to describe those players who are able to predict not only the opposition's next move, but also what their own team's behaviour should be, both reactively and proactively (Singer et al., 1996; Singer & Janelle, 1999). Due to their highly interactive and co-adaptive nature, anticipation is, therefore, important within team sports (Williams & Jackson, 2019), recognised within research, and much sought after by coaches in the preparation/development of decision making (DM) expertise (Causer & Williams, 2013; Morgan et al., 2020).

One key factor that is understood to contribute to such outcomes is the use of task-relevant information. Predominantly laboratory-based research has utilised a myriad of different visual manipulation techniques to identify and understand key differences

CONTACT Rosie Collins collins@brookes.ac.uk Gipsy Lane, Oxford OX3 0BP, UK
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between the perceptual abilities of skilled and novice performers (see Farrow et al., 2018, for review). For example, Williams et al. (2003) aimed to understand whether training could improve novice goal keepers' anticipation responses through simulation training. Using pre-recorded footage of penalty flicks in field hockey, participants were provided simulation training, which included information pertaining to the relevant cues for successful anticipation. During this intervention, participants were also challenged by being provided with occluded footage (240 ms after ball contact) whereby participants had to verbalise the ball destinations and were given feedback on their accuracy. Findings showed that participants in the intervention group (against a "no treatment" control and a placebo video-watching group) improved the speed of their DM (100 ms in laboratory settings and 50 ms in field) but importantly, *not* the accuracy of their decision. These data suggest both the importance of anticipation in efficient DM and support the contention that this process can be taught through verbal instruction and feedback. Additionally, however, this also suggests that effective DM may involve more than just perception (Richards et al., 2017).

Similar use of these techniques is evidenced by Vaeyens et al. (2007) with development soccer players. Participants were categorised by skill level as elite, sub-elite, regional and control (no experience) and, subsequently shown footage of multiple attacking sequences (e.g., 1 vs. 2, 4 vs. 5). To operationalise an anticipatory and DM response, the footage was paused as soon as the on-screen player (representative of the participant) received the ball. Eye-gaze behaviour was used to assess the identification of task-relevant information, as well as the timing and accuracy of each reaction as measures of effectiveness. Notably, participants' visual search behaviour (i.e., number of fixations, fixation duration and order of fixations) varied based on the task context within each scenario. Unsurprisingly, main findings showed a general skill-order effect between the elites/sub-elites versus regional/control participants. Overall, more complex scenarios resulted in longer and less accurate decisions across all skill groups. However, this was not the case when the offensive players greatly outweighed defensive players (e.g., 5 vs. 3), where perhaps the degree of pressure to find a solution was less severe or the DM process was simpler. Importantly, in nearly every condition the elite players displayed more fixations, but of a shorter duration, something that was suggested to have implications for both talent identification and development.

Another such example is Roca et al. (2020) who studied the information-processing of creative expert performers. To do this, soccer players were shown game footage in which a number of possible tactical options were available. Data from eye trackers and post-test verbal reports revealed that the more creative players produced fewer, but more effective, possible options for action during the DM process (see also Johnston & Morrison, 2016; Roca et al., 2013). In short, this research has uncovered processes pertaining to earlier pick-up of important information which allows more time to respond within time-pressured scenarios. Consequently, this helps players to react faster to tactical challenges, perhaps because they need less time, or less information, to spot an opportunity and respond (Lex et al., 2015). As these laboratory studies have progressed, it is clear that data and research designs are increasingly taking into account various nuances of the anticipatory and DM process. However, the focus of this nuance appears to remain within the context of what happens during the experiment itself, failing to capture any detailed insight into the development of such skills from a multifaceted in-game perspective, as understood by the experts included in the research.

As a further mechanistic consideration, much debate still exists regarding the interpretation of perceptual characteristics derived from these laboratory studies (e.g., Johnston & Morrison, 2016; Roca et al., 2020); especially as theoretically positioned within *either* a cognitive or ecological approach. Addressing the former within this theoretical dichotomy, one style of cognitive processing that has received much research attention is called Classical Decision Making (CDM; Mascarenhas & Smith, 2011). This style is characterised as a process of identifying a problem and a general range of solutions through critical, thoughtful analysis before consciously selecting a preferred course of action(s) (Beach & Lipshitz, 1993; 2016). Notably, this style of DM is reported to be relatively slow and taxing on cognitive resources (Collins & Collins, 2019). Another style of cognitive processing is Naturalistic Decision Making (NDM; Kahneman & Klein, 2009; Klein et al., 1993), which is considered the quicker of the two styles, utilising intuitive, subconscious and faster judgements in order to make a decision (Collins et al., 2016). However, even with a heavier reliance on "gut feel", Klein and Calderwood (1991) suggest that many decisions are recognition- and cognitively-based, relying on the decision maker to relate their present situation to a previous experience within memory, known as Recognition Primed Decision Making (RPDM; Klein, 2008). Indeed, it is this fast/efficient recognition, through an elaborated internal representation, which supports the DM process when an individual faces a problem within their environment. In short, search strategies and subsequent actions are *primed by anticipation* whereby priming is the repeated presentation of a stimulus, which facilitates the later effective identification and processing of that stimulus (Segaert, in press). Practically, this can occur either through an RPDM process, a more carefully considered CDM-style internal reflection (cf. Collins & Collins, 2015) or both acting in tandem (Richards et al., 2017), depending on the situational context and demands. An example of this is shown in the research of medical DM, namely amongst ambulance nurses (Gunnarsson & Warrén-Stomberg, 2009). In this context, decision makers utilise several DM strategies as the information available to them evolves. In any case, DM from a cognitive perspective requires some degree of knowledge and experience (i.e., understanding of the situation *and* in deploying the cognitive strategies), especially within novel or challenging situations (Flin et al., 1996), presumably stored in and recovered from, one or more internal representations.

Alternatively, an ecological perspective emphasises the "complementarity of the animal [performer] and the environment" (Gibson, 1979a, p. 56). Seen as an interactionist view of perception and action, the ecological dynamics (EcoD) approach explains DM as an "emergent behaviour" (Araújo et al., 2006, p. 16), continuously derived from an individual's interaction with environmental information, and *not* relying on centralised representations (Araújo et al., 2019). Moving within an environment presents opportunities for action(s), referred to as affordances (Gibson, 1979b), underpinned by the direct perception of different action possibilities. This perspective suggests that expert performers do not become better decision makers "offline" (which the cognitive approach would suggest as a possible strategy), but become more attuned to the perceptual-motor landscape in which they act. Consequently, the perspective suggests this results in a more functional, adaptive and self-organising motor pattern (i.e., better able to differentiate a wider variety of information, increasing the range and economy of the information detection process; Reed, 1996). According to EcoD, a decision is the result of an instability in the athlete–environment system, not directed by a central process (Kelso, 1995). More

specifically, in distinguishing this with the cognitive perspective, "In ecological dynamics, there is no internal knowledge structure or central pattern generator inside the organism responsible for controlling action" (Araújo et al., 2019, p. 10). Indeed, Gibson's (1966) original work, which underpins this approach, suggests perception is *only* derived from information detected by an observer. Reflecting this interactionist perspective, studies from the EcoD perspective have demonstrated behavioural co-adaptation between different players of the same team (e.g., attackers and defenders) as a complex self-organising system. Timing of movements is regulated by key task constraints (e.g., goal location, performance area markings and the ball) leading to spontaneous pattern-forming dynamics emerging and the contextual dependency of decisions (Davids et al., 2013). Accordingly, from this situated perspective, effective DM cannot be evaluated, and therefore developed, in the absence of representative contexts and demands.

The contrasts between these two theoretical perspectives clearly offers a conundrum for applied psychologists and coaches on how best to develop DM skills. For example, whether or not DM can be effectively developed outside of the performance context. Notably in this regard, empirical laboratory studies have begun to probe this issue, showing that advanced information about a likely outcome leads to superior performance under anxiety, despite no change in information-processing demands when not provided with this information (Broadbent et al., 2019). In other words, performance was attributed to more accurate DM ability, rather than a reduction in cognitive demand (Loffing & Cañal-Bruland, 2017). Thus, evidence from controlled studies is starting to test the mechanisms proposed by theory, suggesting that offline processing could indeed be an important factor for in-action DM. Possessing such knowledge which informs action has been termed "contextual priors" and continues to be explored in sport with promising implications for professional practice (Broadbent et al., 2019; Mann et al., 2014).

Reflecting the applied setting, empirical data are identifying the contextual information utilised during team DM; findings which specifically highlight the current lack of consideration and breadth of this complexity within research. Using interviews, Levi and Jackson (2018) found the in-game decisions of eight professional academy soccer players to be influenced by both dynamic and static contextual information. Dynamic contextual information evolves with the situation (e.g., personal performance, score status, momentum and external/coach instructions). Static contextual information equally impacts upon DM, both positively and negatively, and is consistent across the game (e.g., match importance, personal pressure and preparation). Whilst Levi and Jackson concluded that it is imperative to consider the influence of context upon decisions, further research is needed to understand *how* contextual factors combine to influence decisions and, *if* these factors are present during the DM process, *how* they transfer to the action execution itself.

Notably, Levi and Jackson (2018) chose to explore DM in a team sport, due to the number of factors potentially impacting on the DM process (Gréheigne et al., 1999; Malone & Lorimer, 2020). Researchers frequently highlight the interactionist nature of team sport, citing factors such as social values (Bouthier et al., 1995), cost–benefit considerations (Gréheigne & Godbout, 1995) and personal motivations (Bouthier, 1993). Rugby union is, therefore, a suitable domain for research of this nature, due to the characteristic stop-start nature of the game from open play scenarios utilising stoppage time (World Rugby, 2020).

Finally, and also of note, whilst there is much theoretical insight within the literature on DM and some experimental testing of these ideas, there is a dearth of consideration towards how key decision makers understand the development of these skills and abilities in practice, cognitive or otherwise. Whilst ecological advocates consider this a bottom-up process of becoming more attuned, and cognitive advocates suggest a top-down process based on centrally stored knowledge, neither have sufficiently explored how those involved seek to operationalise DM in the real-world training and performance setting, propose our earlier comment when discussing laboratory research.

To summarise, much of the previous literature has been theoretically driven by laboratory studies from either a cognitive or ecological perspective (Roca et al., 2020; Williams et al., 2003). Crucially, there is a dearth of research attempting to explore DM within an individually meaningful, in-game context. As such, an understanding of the complete and personal process is lacking. Therefore, further exploration is needed to provide practical guidance on how best to develop DM within performers. Recent research has taken a step towards this, identifying the existence of contextual information (Levi & Jackson, 2018), however as yet no research has attempted to understand if and how this information extended into performance, especially at the elite level.

Therefore, this study aims to expand upon and extend recent work within academy settings by further exploring the role and development of cognition, understanding and knowledge as it relates to contextual information in elite-level DM. Furthermore, we wished to examine player perceptions of contextual information as understood by those undertaking the DM and its training. Reflecting these contentions, we identified the use of qualitative research methods in order to achieve our aim, to explore elite-level DM within rugby union players, thereby extending the team-based work of Levi and Jackson (2018), against which three purposes were developed:

(1) To explore the macro (higher level, longer and more established factors; e.g., position in the league table), meso (factors emerging throughout the game; e.g., score line) and micro (lower level and quickly forming within the game context; e.g., deteriorating pitch conditions) factors considered when a ball is out of play. Do these prime subsequent decisions, focus and action?
(2) To explore whether those factors then carried through as foci for attention once the game recommenced. Does this priming subsequently operate?
(3) To explore if those factors were selected and developed through training. If so, where do these priming ideas come from?

Methodology

Collins and Kamin (2012) present a three-stage evolution of research; *through* sport, *of* sport and *for* sport. In this circumstance, the latter most accurately reflects the purposes of our work since this research sought to understand the processes that enable DM within the elite-level sporting context. Reflecting our aim and underlying purposes outlined above, we employed a pragmatic approach for this study (Creswell, 2003). Notably, a pragmatic research philosophy offers benefit by focusing on the provision of solutions for relevant and pertinent real-world applied problems. Indeed, pragmatists often

conduct research to find answers for certain questions, or redress key inequities within research, without recognising traditional philosophical dichotomies (Coe, 2012). In this instance, given the stated dearth of player-focused research above, our study was exploratory in nature and therefore required a methodology which would allow the rich experience and expertise of the elite-level participants to be identified. Pragmatism values the outcomes of research more than the philosophical "worldview" that underlies the method (Creswell & Plano Clark, 2011; Giacobbi et al., 2005). Through this approach, we were prepared to not commit ourselves to an ontological or epistemological view of the world and instead, select a methodology most appropriate to the practical problem, provided this use produces findings of practical value (Denscombe, 2007; Morgan, 2007). In this sense, the research can be considered as understanding practice-through-theory.

Participants

Nine male top-tier professional rugby players (M_{age} = 32.4 years, SD = 5.6) were recruited for this study. Purposive sampling (Lavrakas, 2008) was used to recruit participants due to the specific sample criteria required (i.e., key decision makers with elite-level experience). Participants approached were known to the researchers and expressed an interest in partaking. All participants played at Centre or Fly-half, selected because these players have the most touches of the ball in positions where they can dictate what comes next (World Rugby, 2020). In addition, all had experience at the top-tier (M = 10.6 years, SD = 3.2), with five capped at international level (M = 30 caps, SD = 17.6). Two participants were retired from playing and now coaching at top-tier clubs. Notably, and reflecting the pragmatic approach of this research, to avoid a heavy influence of club coaching practice, participants were recruited from four different professional clubs. This study received approval from the University's Ethical Committee and all participants provided signed informed consent prior to taking part.

Research design and interview guide

Building on the work of Levi and Jackson (2018), this research sought a rich picture of participants' personal experiences. As such, a qualitative research approach was employed, allowing for participants' experience and expertise to be probed and discussed. Semi-structured interviews were selected to flexibly engage participants in the topic (DiCicco-Bloom & Crabtree, 2006). Furthermore, semi-structured interviews have been praised for the development of reciprocity between researcher and participants (Galletta, 2012).

A pilot study was completed with League 2 level participants to enhance the reliability of this study and confirm the development of the semi-structured interview guide (Kallio et al., 2016). Feedback from pilot participants indicated that the interview guide was appropriate and had a coherent flow. Consequently, we confirmed the choice to explore the study purposes by asking participants about their experience in stoppage time, through to live play as opposed to dead ball situations (World Rugby, 2020). This was deemed most appropriate as these scenarios require performers to engage in DM and commence action in a short period of time, as the game is still in flow. This differs from dead ball situations which are typically longer in duration but also generate less

pressured situations. The pilot study indicated that an example scenario would help to contextualise participants' responses, therefore a lineout scenario was used. This was selected because the break in play allows the majority of the team to be isolated from the game, therefore Centres and Fly-halves, with supporting players, have to decide from a number of options.

Data collection

Due to national travel restrictions caused by a global health pandemic, all interviews were conducted online and recorded with the participants' permission, conducted by the lead researcher who is experienced in qualitative data collection for research and professional purposes. Following the flexibility afforded by the semi-structured interview guide each interview was idiosyncratic. Participants were able to explore their thoughts at leisure and were only offered occasional prompts or clarifying questions. Interviews lasted between 45 and 123 min ($M = 57.4$, SD = 11), and were concluded once the participants felt they had nothing additional to contribute. The full semi-structured interview guide is shown in Table 1.

Data analysis

Extending the six-step thematic analysis process outlined by Braun and Clarke (2006) and emphasising the pragmatic nature of this study, this analysis used a deliberate "reflexive" approach (Braun et al., 2018). This means that, in contrast to analysis being purely inductive or deductive (against pre-existing theory/findings), data were coded using both inductive (i.e., new insights) and deductive approaches; the latter informed by the research team's applied experiences (37 and 8 years' experience in elite sport, supporting performers up to international level and one with extensive experience within rugby as a player, coach and practitioner at elite-level). In contrast, and positively, the lead researcher had a basic understanding of rugby union as a fan of the sport, without explicit expertise which could bias their view. The team also brought considerable literature-derived knowledge or theoretical knowingness (Braun et al., 2016). Reflecting the pragmatic nature of this research, this allowed the data analysis process to accurately reflect the participants' experiences and therefore provide practical information surrounding a practical problem (Denscombe, 2007), whilst also offering sufficient background to understand and interpret their perspectives (which were later confirmed by member reflections).

As such, each interview was transcribed verbatim, participants were given numeric codes and all identifiable information offered, such as clubs the participants had played at, were removed. Transcripts were read through and initial codes were highlighted using appropriate terms, taking a "revise, retest, revise" approach (cf. Taylor et al., 2021), whereby participant's intended meaning was critically considered against the knowingness of the researchers. Specifically, this knowingness reflected the mechanistic principles outlined by the cognitive and ecological approaches. In this way, data were meaningfully analysed through reflexive, transparent engagement, thus working towards a "richer more nuanced reading of the data" (Braun & Clarke, 2019, p. 594). According to Braun and Clarke (2019), codes do not and should not passively emerge. Instead, they are created by the researchers in an attempt to develop an interpretive

Table 1. Semi structured interview guide.

Open Question to achieve this purpose		Probes if participants do not provide enough detail in their answer	Stimuli to ask for direct comment on, if the purpose is not achieved	What is the purpose of this line of enquiry?
Pre-performance process	*During a ball stoppage situation, where is your attention?*	Is there anything in particular you're looking at? Are you thinking about it? Do **Macro** (Score line, time of the game, position on the pitch), **Meso** (knowledge of the people around you) and **Micro** (position of the players around you) factors effect this?	Are you looking for something in particular? Are there thoughts going into your DM process? Do factors impact upon your DM process? If so, what are they? Do you process the information you're looking for? If so, how?	Establish if there is a use of **knowledge and understanding** to make a skill execution decision, and if cognition is underpinning visual search strategies. Aim to develop a rich picture of the elements players look at/think about on a macro, meso, micro level.
In performance process	*Once the game restarts, where is your attention? (foci for attention)*	Are you looking at the same things? Fewer/more? Are you thinking about these factors now? Do **Macro**, **Meso** and **Micro** factors effect this? Does information carry through into action? If so, what?	Are still you looking for something in particular? How does the information impact action? Are there thoughts whilst IN your DM process? If so, what are they? What possible factors impact upon your DM process?	Explore if understanding develops through action, and how/if it is drawn upon during action. Does cognition stop when the ball comes into play?
Development of cognitively primed understanding, if it exists	*Where has this ability/skill come from?*	Can you recall specific activities, practices or coach inputs that developed these skills? Is this a skill you have improved over time? How did you learn it initially and how did/do you develop it? Is this something that can be taught, or is it developed through practice?	What factors affect the efficacy of this skill?	Establish if use of knowledge is a developed skill, and if implementation requires recognition/deliberate application.

story of the data. Therefore, the two researchers conducting this stage of the analysis took time to reflect upon the selected raw data codes and assessed these against their own theoretical assumptions before formulating a complete structure. A small number of adjustments were made that served to clarify the link between raw data code name and the intended meaning by the participants, therefore the coding process was internally scrutinised (Braun & Clarke, 2019).

Reflecting these qualitative innovations by Braun and colleagues, raw data codes were compiled in order to identify similar patterns, known as shared meaning units (SMUs; previously "lower-order" themes), then hierarchical central organising concepts (COCs; previously "higher-order" themes) were generated to unite the SMUs. Next, all researchers reviewed this structure to confirm the collaboratively constructed COCs (Braun et al., 2018). Through this process, concepts were defined and write up of data commenced using a selection of the most appropriate quotes.

Trustworthiness

In addition to the steps outlined above, we sought to ensure maximal trustworthiness of these data. As stated by Smith and McGannon (2018), historically used processes such as member checking and inter-rater reliability are no longer recommended on the basis that "theory-free knowledge is unachievable and that realities are subjective, multiple, changing, and mind-dependent" (p. 112). Furthermore, participants and researchers are not able to extract themselves from their own experiences, and therefore biases (Denzin, 2017).

As such, once completed, member reflection was utilised as a further characteristic of the pragmatic philosophy employed. Member reflection is the process of sharing ideas and findings with the participants, not for verification of results, but to more fully explore the topic of interest (cf. Smith & McGannon, 2018). Instead of aiming to remove contradictions in the data, as is the aim of member checking, this process aims to highlight and understand these contradictions to inform data interpretation as it relates to their world (Schinke et al., 2013). For example, reflecting our decision to recruit across multiple professional clubs, variation within these data could be further explained as a result of specific practices/cultures of training within each setting. Drawing upon Harvey's (2015) dialogic approach, we shared the generated codes and COCs with participants for their comments in order to co-construct and understand the findings. To ensure accurate recall, and therefore an effective member reflection process, this took place no more than three weeks post-interview. Following this, all participants responded, confirming that their views were effectively represented and the generated codes were an accurate depiction of their views.

Results and discussion

During the interview and data analysis process, it became clear that study purposes one and two were inextricably linked. Therefore, we present the COCs which answer these purposes and discuss them together (Table 2). Following this, we employ the same process for purpose three (Table 3). Accounts from participants are utilised throughout these findings, however, we also direct readers to these tables for evidence of additional exemplar quotes from other participants.

Purposes 1 and 2: Considered factors, contextual priors and priming

Against the first two study purposes, namely, the macro, meso and micro factors that might impact decisions and how these factors are carried through into skill execution (Table 2), COCs emerged to explain a process that performers experienced when making and processing decisions. Interestingly, these support and extend the findings from Levi and Jackson (2018) as similarly, there were several contextual factors performers were considering both during stoppage time and when the game restarted. Whilst Levi and Jackson identified static and dynamic factors, the findings from these participants identified the following: pre-determined, evolving and feel factors as subthemes of "Contextual Priors".

Table 2. Thematic Analysis Pertaining to Purposes 1 and 2.

Exemplar Quotes	Raw Data Codes (*N* participants)	SMU	COC
We know everyone on the pitch what you're about as players … I'll know every other player what they're about.	Consideration of own team (9)	Pre-known Factors	Contextual Priors
The factors that are probably affecting the conditions of the game so you talk about a 4G pitch whether it's raining whether it's windy um definitely have a massive effect on um what decision you make.	Weather/ Environment (9)		
If you're having a bad day at home of course it's gonna affect your main decision in a highly stressed job.	Extraneous pressures (6)		
It's just knowing how I can move, which direction I can go quickest in.	Skillset/Ability (6)		
Where is the opportunity to apply pressure on the opposition? And where are the opposition's weaknesses so even psychologically where are the opposition's weaknesses under pressure? … their hooker's struggling to throw in, it doesn't matter if we kick the ball out we'll get into their lineout?	Knowledge of the opposition (9)		
You're trying to make a decision on 'is this the right time to go again? is the referee pinging for penalties … Very, 50/50?'.	Officiating (5)	Evolving Factors	
So you know um if you're going into the last 5 min of the game and you're losing and you need to score you need to score a try … you know the factors around you that have a big impact on the decisions that you make.	Scoreline (8)		
So the scoreboard and the clock, we talk about points and pressure.	Time on the clock (9)		
We're all on the same page and we're all understanding that we're doing it for the right reasons … that's when you need to kind of be in control of your internal plan as a group.	SMM strategy (9)	"Feel" Factors	
I think it's sort of an awareness, it's an awareness of that momentum and those building blocks.	Momentum (8)		
You've got to have an understanding of how the game feels … you have a feeling for how the game is maturing or how the game is playing out.	Knowledge of the game (7)		
You're assessing, it's a poor kick by the opposition I've run onto the ball, it's a fragmented defensive in front of me that I have my support players working back and giving me width, the opposition are condensed so then they're processing quickly … the best players think very instinctively, they have trained these moments probably a lot in their own head but they've also trained them in training.	Developed instinct (6)	Developed Instinct	Primed DM
People look and go 'bloody hell how are they making that decision?' but … we do it day after day like it becomes quite simple … it does feel fast but it's years and years of knowing it.	Embeddedness (8)		
What our players are saying to me, where they feel that space is, the more information I can garner, the better it is for me.	Communication from teammates (9)	Thinking in Action	
As a player and a leader you know that they're not gonna win this line out, the opposition's all over them so let's go to the other plan.	Context in the game (8)		
The more you know about someone the more you're likely to pre-empt what's gonna happen.	Anticipation (5)		
He can read a picture and be a maverick, his best element is he drills this system day in and day out and if you're a metre out of position you're in the wrong position and he drills it, so when he's sees it, he knows it on.	Recognition (8)	Visual Information	
	Experience(5)		

(*Continued*)

Table 2. Continued.

Exemplar Quotes	Raw Data Codes (*N* participants)	SMU	COC
Probably 95% of the time I've been in the position before … used up knowledge I've had in the past or stuff I've done wrong or right in the past.			
When you look and you see people's body language … where they're propelling their energy, are they sinking in on one person in particular how quick can you then go to that option and that reading of body language which is a millisecond is basically one of the factors why you can be successful, but only because you understand what the those picture are now.	Understanding visual cues (7)		
It's an understanding of your options. You're almost primed to know that those options are available to you.	Priming (6)	Priming	
Training may look brilliant and they might run it brilliantly, but if they haven't experienced this chaotic side of the game then how can we expect them to have the ability to deal with it whenever they play on match day.	Preparation (9)		
People weren't going to the space inside him, and once you actually coaxed him to come towards you, we can exploit him. So that was just through analysis throughout the week. So we know that he, the individual does that, so then we can pick him off.	Performance analysis (9)		
So that vision you have off the ball is very key for guys that you make breaks and then obviously that physical element helps if you're a bit stronger and a bit quicker that you can push through those half breaks and things like that.	Physiological factors (7)	Physiological	Considered factors
You might get the call from the coaches to kick the balls because they want territory, but you might make a call on the pitch that you feel we haven't played enough with the ball in hand.	Adaptability (5)	Psych Factors - Developed	
I do a lot of visualisation and imagery. I'm imaging the ground. I'm imagining grass, it's fake, it's real, wind, rain, whatever … Imagery, a lot on my defence around my tackling. That's the biggest thing I work on and X-Factor stuff, things that I might do once every ten games. I try to do that weekly in my head.	Mental tools (4)		
… good players play makers will make the right call 9 times out of 10 instead of 6 times, so having those other elements are big factors to the decisions on the ball um but I think that's a bit of the game where having confidence, trusting training pays off.	Confidence (9)	Psychosocial	
One thing that's important to note, when you're playing with somebody who's making similar decisions well we're all making decisions together.	Values/Culture (8)		
My attention is on my role within that, so you know that decision may be that we're going to push the ball to win because there's an opportunity on the outside so what's my role?	Role clarity (8)		
There's programmed predetermined decisions in the sense that you've got a selection and it's trying to figure out which is the best one.	Options (9)	Weighing up action	Cognition
When that picture doesn't present itself you might panic and try to throw a pass which isn't on. I've learnt you're going to have to cut your losses and carry the ball in, and be patient, eventually something will present itself.	Decision against action (4)		
I'm actually quite frustrating to coaches. I'm very inquisitive, so I'd always ask, 'why are we doing that?' and it got me into a bit of trouble in the past because I think an insecure coach would feel like you're questioning him, I just want to know why.	Explicit knowledge/ understanding (8)	Explicit Understanding	

(*Continued*)

Table 2. Continued.

Exemplar Quotes	Raw Data Codes (*N* participants)	SMU	COC
Well I think it [thinking] becomes more bespoke, it becomes narrower on the task at hand and what you've got do. It's not that you're forgetting everything. It's just you sort of compartmentalise … you're just purely focusing on what the action is and then stay very much in the moment and the present.	Thinking about the task (7)		

Of interest are the breadth of factors identified, from micro (pitch conditions) to macro (league position) in nature, meaning that players had to be constantly aware of and assessing the evolution of the game. As Participant 3 explains, "you're in constant communication with people, that allows you to build a structure of the game". Some of these factors were pre-determined, which led to a primed effect (explored later), but others developed as players engaged in the game. Participant 8 summarised these as "points and pressure", referring to the constant consideration of context required.

The impact of these factors also extended to subsequent skill execution. Evidently, there is a clear "priming" of DM created by overtly led consideration and cognition, which can be seen in the codes that compromise "Contextual Priors" (Table 2); for example, advanced knowledge of the opposing team. As Participant 6 identified with regards to one opponent: "As soon as he does that, as soon as he starts to get high, that's when you can throw the pass". This knowledge allowed players to anticipate opposition behaviours, since they were primed to search for and recognise these and act accordingly (Klein, 2008; Segaert, in press). For example, "working people's body positions out to push through contact or break the line" (Participant 4) and "so people have read his body language and decided that's what he's gonna do" (Participant 2). This RPDM style suggests that participants were viewing the "pictures" presenting themselves in the evolving game but utilising cognition, likely stored as an internal representation, to execute the skill (cf. Raab & Araújo, 2019). These findings could also be seen to extend the laboratory-based research on anticipation and DM. For example, Williams et al. (2003) identified that simulation training increased the speed of DM through anticipation but not the accuracy. It is possible, therefore, that priming for contextual information could have facilitated this impact.

Furthermore, players suggested that they were thinking, plotting and planning against a variety of different factors, *during* skill execution; for example, knowledge of the opposition team, which was mentioned by all participants (Table 2). Participants were becoming more aware of their opposition as information became available to them:

> They've overcommitted to a breakdown, so there's three in the breakdown, I'm already at seven. They've got two in the backfield which I know, that gets me to nine and then suddenly I've got half a pitch to go here, I know it's on, it's just simple maths (Participant 9)

Indeed, this finding supplements that of Vaeyens et al.'s (2007) eye tracking study. As demonstrated here, performers are deliberately accounting for the opposition and planning accordingly, as opposed to being directly afforded this information. Therefore, this helps to explain why perceptual processes and DM responses were less efficient with increasing scenario complexity (Vaeyens et al., 2007).

Table 3 Thematic Analysis Pertaining to Research Question 3.

Exemplar Quotes	Raw Data Codes (*N* participants)	SMU	COC
Watching and doing really. Watching a lot of film, and learning the triggers of very good players and people making good decisions … You've gone from trying it, to learning it, to copying it, to understanding it, to then actually being able to articulate and tell other people why you understand.	Process of learning DM (9)	Learning DM	Training DM
Yeah, decision making can definitely be developed and taught. It's through work.	Belief DM can be learned (8)		
Explaining stuff to academy boys, sitting down, going through clips, that was a huge help for me to understand what I should be looking at.	Coaching others (9)	Better comprehension of DM	
I found a coach who was number 10 who can really critique my decision making … my game has gone to a whole new level based on one coach who can really help my decision making in game.	Coaches explaining DM (8)		
If you've got that in the locker already which you hope a professional rugby player would have the ability pass kick under pressure, run the right lines, that when you add a drill where you don't have to worry about that it becomes more decision making based. Because already those fundamentals of passing and kicking then that's the bit that you rep and you're constantly adding to.	Drills (4)	Coaching Tools	
It goes back to the training weeks in the months before and getting to know, working in very high stress situations when you're over fatigued in training or you're mentally challenged during really hostile situations.	Pressure training (2)		
We do scenarios in training, like scenario base drills, like 'right lads you've got 1 ½ minutes left on the clock you've got 3 points left on the scoreboard you're in this part of the field, what do you do?'	Scenarios (6)		
This is all been a process throughout the years, if I'm looking at my own individual situation, whereas when I was younger, I went into a game and I probably look for like two or three areas. I would have been very individualistic in terms of what defender is weak so I can beat them. Whereas now I'll look for individual defenders as an individual for myself.	Background in sport (5)	Development of DM	
You might not have a quick ball but then someone might bust a tackle and you're suddenly 30 metres down the pitch so the context's changed, what will he do now so that's a really good way of looking at it, what is the context of that moment.	Evolving game (5)		

As suggested by Broadbent et al. (2019), "Contextual Priors" inform active play, providing an alpha plan of actions: "so that decisions can be sometimes pre-planned, but you're just waiting on the best opportunity to pull the trigger on that decision" (Participant 1). Of course, these alpha plans should be shared, as Participant 5 explained. "If I see some opportunities that are open to myself and I communicate that to the players around me then we've got much more chance of you capitalising on that". Interestingly, these cognitions were ever-present, but were reported to narrow in focus, or as Participant 9 suggested, become more "bespoke", going on to state "it becomes narrower on the task at hand and what you've got to do". These findings support cognitive theories, such as Meshed Control (Christensen et al., 2016), which suggest that skilled performers' thinking is not uniform depending on the nature of the task. Automated movement control allowed athletes to attend to higher implementation components, such as strategy (cf., Carson & Collins, 2020).

Importantly, through the change into this active phase, participants were overtly considering what to do, but also what *not* to do, against the emerging picture. For example, "the defence has tightened up, let's play around them or they're wide, we can play through them" (Participant 6). In short, players were thinking *as* they played *and* before the game restarted. Seemingly whilst a player might observe an opportunity for action, or an affordance (Gibson, 1979b), they also base their decision on the context and understanding of the game. This is exemplified by the "decision against action" code, as Participant 9 stated:

> if there's space in the back-field, you know you can kick it there. But they're very vulnerable anyway… they've got three defenders, and it's a five-on-three. Then you're probably keeping the ball in your hand. So it's like 'which one of these decisions will punish them more?'

Of course, this thinking is still high level, and does not extend to more fundamental and well-rehearsed actions as "how and when do I pass". Interestingly, all participants suggested that these lower-level component skills carried out in-action, occurred unconsciously. When probed, however, what emerged is that the method was consciously developed: "There are unconscious decisions that you're making because you've done it before but they are definitely at the forefront of your mind" (Participant 6). This seemed due to the players experience; for example, "I've been in the position before … In some way, shape, or form, you've seen it" (Participant 7).

Unsurprisingly (to us at any rate), these lower-level actions are seemingly controlled unconsciously and could *perhaps* be explained by the EcoD approach. Importantly, however, our data could be explained equally well by the implementation control element of the more cognitive meshed approach (Christensen et al., 2016). Discriminating between these theories was not the purpose of our investigation but clearly this merits further study.

Returning to our main purposes, however, there is no doubt that cognition is the primary driver as understanding of the information participants perceived was still necessary. For example, "that's why I could be successful in making a pass, because I've looked and yeah he's done exactly what I thought he'd do" (Participant 2). The process of plotting and planning is decidedly cognitive, as evidenced by Participant 4:

> you're assessing, it's a poor kick by the opposition, I've run onto the ball, it's a fragmented defensive line in front of me, I have my support players working back and giving me width. I'm there, the opposition are a bit condensed so then you're processing that quickly then to make sure you understand 'I can just shift the ball quickly'.

Purpose 3: Developing the Skill

Of course, if DM and skill execution *do* rely on underpinning cognition, this must be developed in some way. This led to our final purpose (Table 3). As already identified, several players spoke initially about the processes as "instinct", but went on to state this instinct, explicitly seen as anticipation and game sense (e.g., "Rugby is second nature, but it's safe to say that knowledge is something I've been building" – Participant 7), had been developed through many hours of reflection and discussion, led by overt coaching. This is seen through a plethora of quotes in Table 3 and in further examples such as Participant 8 who stated, "I think the best players think very instinctively in the moment … they have trained

these moments probably a lot in their own head but they've also trained them in training". Such a DM approach is aligned to the process of RPDM (Klein, 2008), in that participants have engaged in the prior explicit generation of options, through training and experience, which enables them to quickly identify and confirm the basis on which to act.

Regarding the contextual factors, it appeared that many decisions are primed through extensive performance analysis and scenario-based training. Utilising these coaching tools allowed participants to better understand and consider their teams' approach to different circumstances. For example, as Participant 4 described, "they'll tell me 'you're down by two points, two minutes left', and then I bring the huddle in and we decide". These SMUs often interacted, as players found themselves constantly exploring and understanding plans specifically related to their next competition. This was eloquently described by Participant 1 who stated, "you spend all week learning theories and then Saturday is just about putting them into practice" thereby, identifying the importance of explicit exploration within training. This supports contentions by Broadbent et al. (2019) who identified that providing information, such as "Contextual Priors", supported their participants' performance effectiveness although it did not result in lower processing demands in terms of mental effort. So, even with prior knowledge, data from this study and that of Broadbent et al. explain cognition as being applied within the performance context.

Some players identified that key coaches had an impact on their DM, by better explaining what the players should be looking for. However, eight of the nine participants discussed the impact of explaining, or coaching, DM to junior players as a key turning point for their own skill. For example, Participant 6 stated:

> when I'm coaching them I'm like 'no stand here, stand a few meters back, what are you looking at? are you looking at him? are you looking at that area of the pitch? are you looking at the depth?' and they're like 'no not at all'. I'm like 'OK' so these sort of things are just constantly going on in my head.

Such findings suggest that possessing explicit knowledge and understanding of their role could also support effective DM and its execution. It would seem that, according to the quotation above, the acquisition of DM is cognitive and not emergent (Araújo et al., 2006) and, that metacognition can act to reinforce DM skill at the elite level when coaching.

Finally, participants expressed the importance of the evolution of rugby and their background within this sport, noting that this growth was essential to their effective DM processes. For example, Participant 6 stated, "If I knew even half the knowledge I have now when I was 21, I'd love it", which demonstrates the necessity to learn and build upon your understanding. Notably, not only did this knowledge support players' primed decisions, but also built a richer picture of the contextual factors considered. As Participant 5 exemplifies, "I have to struggle and scramble to cover that option and you'll see it a lot … almost the more you know about someone the more you're likely to pre-empt what's gonna happen". These findings, and those in Table 3, demonstrate the importance of the coach's role; not just as a facilitator of learning, or dare we say a constrainer of the environment, but as taking a leading role in supporting the explicit knowledge and understanding each player develops for effective on-pitch cognition.

Evidently, the findings here highlight the explicit importance of the coach and indeed the personal process of coaching, in order to develop the expertise needed to be an effective decision maker at the elite level. Richards et al. (2012) promoted the role of

reflective practice to promote both coaching expertise and athlete performance, identifying the importance of "reflection-on-action" to enable both "reflecting-for-action" and eventually "reflection-in-action".

Conclusion and implications

Due to the explorative nature of this work, through the use of interviews, we were able to seek clarity on the process of DM as experienced and executed by elite-level participants, which has, to date, been lacking. In presenting this study, we were pleased to support and expand upon the findings of Levi and Jackson (2018) which identified a number of factors players considered as part of their DM process. We also identified several factors, or contextual priors (Broadbent et al., 2019), that were influencing and impacting upon the participants' DM. More pertinently, however, our data extended current knowledge by demonstrating that these contextual priors continued to influence the DM process through to in-action, seemingly acting under a priming effect (Klein, 2008; Segaert, in press). These findings suggest that this priming allowed the participants' cognitions to narrow and focus on more hierarchically complex elements of the game (similar to the suggestions of Christensen et al., 2016), whilst still being able to recognise, process and act upon the evolving performance landscape. We would suggest that this is likely facilitated by an internal or mental representation of the participant's skills (Raab & Araújo, 2019) and practitioners should consider deploying strategies in order to enhance this, such as motor imagery training (Frank et al., 2014; Schack et al., 2014) which has been identified as an effective tool to enhance practice.

At this early stage of exploration, based on players' and coaches' perceptions, both the cognitive and EcoD approaches could contribute to the parsimonious explanation of these data, but in delineated ways. We suspect that protagonists of either perspective may question the interpretations, through the use of esoteric terms such as "perceptual attunement", or request further mechanistic explanations of the EcoD approach. As pracademics, however, we feel that the explanations offered for this topic are both the most parsimonious *and* most reflective of participants' views who have engaged in co-construction of the findings. In essence, athletes train and are coached to achieve *understanding* of their performance environment. Thereby, they are considering contextual factors, sometimes extensively, before action, utilise recognition priming in order to execute these decisions and, finally, continue to consider all this whilst in-action. These key findings do extend current understanding, because they suggest a continuation of knowledge from pre- to in-action DM. Of course, further consideration is needed to understand how novice athletes might use this information.

This study was not without its limitations. Seeking retrospective accounts is not without risk and this information was not formally triangulated. To better understand the information offered by participants, we observed game footage of all active players, identifying that participant's behaviours fully supported their self-reported actions; however, this was not a formal aspect of the research and would warrant further exploration. This notwithstanding, we see the level of play and experience of the participants as being a particular strength. Participants have been playing for many years and *should* by now know what they are doing and why (Thomas & Thomas, 1994), as is demonstrated by their continued success. The inclusion of two ex-players, now coaching, adds to the level of critical reflection offered. Interestingly, this strength

could be offered as an implication. The knowledge these participants hold should be considered by coaches as a further tool in training. For example, as highlighted, the participants felt that coaching junior players in their team advanced their own understanding and subsequent performance through metacognitive processes.

Further implications of this research are impactful for coaches and practitioners alike. As presented, the role of understanding is often neglected within research and practice. Therefore, coaches and practitioners should make a concerted effort to encourage understanding during player development (cf. Price et al., 2019), both of contextual priors and recognition-based action, thereby enhancing the priming effect. Moreover, whilst we suggest there is a mechanistic split between technique (e.g., how/when to pass, or how to tackle) and tactics (e.g., who to pass to or when to tackle), clearly both must be tightly integrated (Carson & Collins, 2020). It would appear there is merit in developing these separately *and* together for eventual elite-level performance (cf. Richards et al., 2017).

Moving forward, future research should look to confirm what players report using performance analysis (i.e., match analysis to see if what players say they do is what they actually do). A stimulated recall could be another potential process, although interestingly all of the players reported using this as part of their own processes in preparing for and following games. However, this work shows a strong relationship between what players say they do and what they actually do do! Notably, active and involved cognition was a consistent feature of all players' DM as their play appeared to be a form of "muscular collision chess" (Participant 6).

Disclosure statement

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ORCID

Rosie Collins http://orcid.org/0000-0002-0794-6128
Dave Collins http://orcid.org/0000-0002-7601-0454
Howie J. Carson http://orcid.org/0000-0002-3785-606X

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