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Abstract

The aim of this exploratory study was to investigate if there were differences in perceptual-cognitive skills of sub-groups within an elite (full-time professional) Australian football (AF) team. Players completed a video-based test, measuring response accuracy, consisting of three sub-tests (pattern recall, ruck cue utilization, and decision-making with the ball) using clips from 2010 Australian Football League (AFL) matches. Forty-six males (M age = 22.0, SD = 3.4 years) were stratified in three ways for analysis: a) *highly skilled* and *skilled* decision-making groups, based on seven coaches' ratings of decision-making skill; b) *midfield* and *key position* players; and, c) *experienced* and *inexperienced* players, based on the number of AFL games they have played (e.g., < 25 or 25+). No significant difference was found between the *highly skilled* and the *skilled* group for total test score (p = 0.04). The *highly skilled* group did, however, perform significantly better than the *skilled* group (p = 0.01) for the decision-making with the ball sub-test, but not for the pattern recall and ruck cue utilization sub-tests. No significant differences were found between the *midfield* and *key position* players, or between the *experienced* and *inexperienced* players. It appears that the more complex and realistic a video-based task is, the more likely perceptual-cognitive differences will be found within elite AF players. The study compared players at the elite (full-time professional) level, rather than comparing expert and novice participants, and found some perceptual differences between highly skilled and less skilled players.

Keywords

decision making, pattern recall, visual cues, pattern recognition, visual perception, sports

Introduction

High level perceptual-cognitive skills are essential traits for expert sporting performance (Carling, Reilly, & Williams, 2009; Wisbey, Montgomery, Pyne, & Rattray, 2010). In invasion games, such as soccer, hockey and Australian football (AF), the aim is to score more than the opposition team by penetrating space to score or defending space to prevent scoring (Breed & Spittle, 2011). This requires players to absorb relevant information from a complex and rapidly changing environment, and then use this information to make a quick, accurate decision about an appropriate response (Williams, Davids, J. Williams, 1999).

Australian Football (AF) is the most popular football code in Australia and at the elite Australian Football League (AFL) level players are full-time professionals (Tangalos, Robertson, Spittle, & Gastin, 2015). The sport of AF is arguably the most complex invasion game, with a total of 36 active participants on a large field (approximately 160x140m) and for a longer duration (average 125 minutes) than any other football code (Reilly & Gilbourne, 2003). While trying to absorb a range of perceptual information, players must also perform a wide variety of technical skills including kicking, handballing, marking, bouncing, and tackling, as well as run an average of 13.2km per game (Wisbey & Montgomery, 2016). The evolution of Australian football has led to rapid changes in the physical and perceptual demands on elite players (Gastin, McLean, Spittle, & Breed, 2013), with AF less researched than other invasion sports (Gastin, McLean, Breed, & Spittle, 2014).

Research of perceptual-cognitive skill (e.g., pattern recall, pattern recognition, advanced cue utilization) has commonly employed an expert-novice paradigm in order to investigate and quantify the differences between experts and novices across a range of sports and laboratory tasks (Vaeyens, Lenoir, Williams, & Philippaerts, 2007). For years, researchers have attempted to identify not only how experts and novice performers differ, but also how elite athletes develop these essential perceptual-cognitive skills (Williams & Ford, 2008). Due to the difficulty of capturing perceptual-cognitive skills in a field setting, the components of anticipation and decision-making are often measured separately in a laboratory, using a representative task (Williams & Ericsson, 2005). In AF, obtaining valid measures of performance during match play is even more difficult due to the complex interaction between physical, technical, and perceptual-cognitive skills (Sullivan, Bilsborough, Cianciosi, Hocking, Cordy, & Coutts, 2014). While perceptual-cognitive skills have been explored in a range of sports, albeit more often in interceptive sports than in invasion sports (Mann, Williams, Ward, & Janelle, 2007), there is a particular lack of published literature regarding anticipation and decision-making in AF. Therefore, the reviewed literature will focus on the findings related to invasion games that are similar to AF, such as soccer, hockey, and rugby, which involve two teams of players, offensive and defensive tactics, and divided attention between the ball and the surrounding participants (Breed & Spittle, 2011).

Early pioneering research by de Groot (1965) and Chase and Simon (1973) in recalling chess pieces by world-class players versus novices provided a framework for investigating the pattern recall capabilities of athletes involved in competitive ball sports (Williams & Ford, 2008). Experienced players have shown to be significantly more accurate in recalling positions than inexperienced players when viewing slides with structured plays, but not unstructured plays, in basketball (Allard, Graham, & Paarsalu, 1980) and hockey (Starkes & Deakin, 1984). Advantages in pattern recall ability are, therefore, thought to be attributable to an enhanced sport-specific knowledge base rather than improved short-term memory function (Williams et al., 1999). Later research has tended to employ the use of video, rather than slides, to represent more closely a realistic environment (Mann et al., 2007). Research using short clips of play has shown that experts perform significantly better than novices on recall tasks in structured situations in invasion sports, such as basketball (Allard & Burnett, 1985) and soccer (Williams & Davids, 1995; Ward & Williams, 2003).

Tests of pattern recall and pattern recognition are both employed to investigate the memory processes of athletes (Spittle, Kremer, & Hamilton, 2010). It is suggested that experts are able to group, or *chunk*, information into meaningful units, which facilitates anticipation by enabling emerging patterns to be recognized (Tenenbaum, 2003). One pattern recognition study in AF stratified 30 elite players as expert and non-expert decision-makers (Berry, Abernethy, & Côté, 2004). Participants were required to view short clips from AF games and attempt to recall the pattern of play by positioning all players shown in the final moment of the video segment on a representative display. Expert decision-makers were significantly more accurate than non-expert decision-makers on the test.

The technique of temporal occlusion reveals if participants are able to utilize early cues to assist anticipation, which is considered vital in most sports (Spittle et al., 2010; Berry et al., 2004). Experts have been found to perform better than novices on a range of simulated occlusion tasks, such as anticipating soccer pass destination (Williams & Davids, 1995), dribble direction (Ward & Williams, 2003), intercepting a soccer pass (Williams & Davids, 1998), and anticipating a direction change in rugby (Jackson, Warren, & Abernethy, 2006). In AF, two players, known as ruckmen, run and jump to compete by hitting the ball to teammates, which requires the midfield players to anticipate the force and direction of the tap at the start of each quarter and following each goal scored. It is thought that if a team can consistently win possession of the ball from center bounce contests they are likely to win the game (Madden & Flanigan, 2010).

Decision-making has been recognized as vital to expert performance in invasion games (Breed & Spittle, 2011; Williams & Reilly, 2000), but has been examined to a lesser extent than anticipation, as it is very difficult to measure due to its many behavioral and cognitive components (Carling et al., 2009). However, some studies have shown that by physically responding to visual cues (Vaeyens et al., 2007; Helsen & Starkes, 1999) experts have been more accurate than novices in predicting the outcome of a decision.

Tests of pattern recall, pattern recognition, advance cue utilization, situational probabilities, and strategic decision-making have commonly employed an expert-novice design, with the aim of comparing two groups of athletes from different levels of competition. Research has consistently demonstrated that experts perform better than novices on a variety of tests across a range of sports (Mann et al., 2007); however, there is a paucity of research examining AF. For example, a meta-analytic review of 42 expert-novice studies by Mann et al. (2007) of perceptual-cognitive skill in sport reported that experts were more accurate at decision-making ($r = 0.31$) and faster at anticipating ($r = 0.35$) than their novice counterparts (medium effect sizes). When broken down into the different components of perceptual-cognitive skill, experts were found to have superior response accuracy to novices, with effect sizes ranging from $r = 0.17$ for pattern recall through to $r = 0.42$ for strategic decision-making tasks (small to medium effect sizes). When invasion sports were investigated, experts were found to be more accurate ($r = 0.28$) and faster ($r = 0.37$) than novices across a variety of decision-making tasks (medium effect sizes).

By comparing experts and novices, it is possible to begin to understand how certain athletes attain a higher level of success than others; however, this approach also has its weaknesses (Swann, Moran, & Piggott, 2015). The definitions of expert and novice are not universal, and many studies have interpreted the terms very differently. Nonetheless, an extensive literature base exists that consistently demonstrates the superiority of experts' perceptual-cognitive skills compared to novices. While it is possible to distinguish between experts and novices, these findings have limited practical relevance. For example, it should not be assumed that all athletes within an expert group are equal in terms of perceptual-cognitive skill. It is believed that where some athletes may lack in one area (e.g., perceptual-cognitive skills), they make up for it with exceptional abilities in another area (e.g., speed and agility [Williams & Reilly, 2000]). Therefore, it seems there is little point in adopting the expert-novice approach in future research.

An alternative to examining heterogeneous groups is to investigate differences within a group of similar skill levels. By examining an expert group, the role of perceptual-cognitive skill in expertise may become clearer. For example, if the best on-field performers produce higher test scores than the worst on-field performers, the importance of perceptual-cognitive skill could be supported. Also, subtle intra-group differences may be revealed (Savelsbergh, Van der Kamp, Williams, & Ward, 2005), which could assist in discovering how exceptional athletes perform successfully (Williams & Ford, 2008). For example, Berry et al. (2004) compared pattern recognition of expert and non-expert decision-makers from the same elite competition of AF; and Savelsbergh et al. (2005) divided an expert group of 16 soccer goalkeepers into successful and non-successful anticipators, based on their scores from a previous video-based test. Maarseveen, Oudejans, and Savelburgh (2015) investigated differences in pattern recall skills within a group of sub-elite female soccer players by comparing those in the first year of a talent program with those in second and third year, and they found differences in anticipation of attacking and defensive patterns. Recent studies in AF have used expert coaches' perception of players' performance as a criterion measure of match performance (Sullivan, Bilsborough, Cianciosi, Hocking, Cordy, & Coutts, 2014), and have been able to predict in-game skill performance (Tangalos, Robertson, Spittle, & Gastin, 2015). Differences in decision-making performance in representative decision-making tests could be compared with coaches' ratings of skill to determine the relationship between test scores and decision-making skill in elite samples. Studying differences within an expert group is rarely used, most likely due to the difficulty in obtaining a good sample size of elite athletes (Williams & Ford, 2008).

Discovering whether a test can differentiate between closely matched individuals (e.g., highly skilled and skilled decision-makers from an expert group) is more useful, theoretically and practically (Dicks, Davids, & Button, 2010; Muller, Brenton, Dempsey, Harbaugh, & Reid, 2015). Results from this approach could be used for talent identification, as well as the development of perceptual training programs. A multidimensional assessment of a similar group of athletes, testing a number of components of perceptual-cognitive skill, would be ideal to gain a more comprehensive understanding of this area of research.

As well as stratifying an expert group of athletes in terms of perceptual-cognitive skill level, dividing a group into player positions has also been suggested (Williams & Ford, 2008). An advantage of this approach is that it becomes possible to ascertain whether certain components of perceptual-cognitive skill (e.g., pattern recall) are superior among certain positional roles. A small number of researchers have chosen to employ this approach and investigate differences in positional roles within a group of similar playing level (Millslagle, 2002; Williams et al., 2008). For example, Millslagle (2002) examined the recognition of basketball situations among the various playing positions of an experienced group of men and women basketball players, finding that recognition accuracy was greatest for the guards, compared to forwards and centers. Williams et al. (2008) reported that expert defensive soccer players performed significantly better than expert offensive soccer players on an anticipation task, despite tests being presented from both an attacking and defending perspective. Bruce, Farrow, & Raynor (2012) compared skilled and novice female netballers on a video-based decision-making test of scenarios from three different positional areas, with players completing the scenarios from each of the positional roles. Limited evidence supported that decision making was specific to position.

Apart from these exceptions, the area of player positions in perceptual-cognitive expertise is under-researched and in need of attention. Again, these studies have generally compared elite and novice performers. Studies identifying meaningful differences within elite groups are lacking, which would make video-based decision-making tests practically useful at higher levels (Muller et al., 2015). If experts demonstrated similar skills, this might be useful in understanding the transfer of perceptual-cognitive skill and the influence of expertise and experience (Rosalie & Muller, 2012). Evidence for perceptual-cognitive skills being relevant to a specific position may be found if players from one position perform better on perceptual-cognitive tests than players from another position. If tests were able to distinguish between player positions, this type of approach could be useful for future research. This type of study would add to the literature in terms of the role of perceptual-cognitive skill in expertise, as well as whether video-based tests are able to separate players based on their field position, indicating that perceptual-cognitive skills are developed differently between positional roles.

In summary, sporting expertise requires a complex interaction between a range of domains including physiological, technical, emotional, and cognitive (Janelle & Hillman, 2003). Within the cognitive domain, there are two main perceptual-cognitive skills: anticipation and decision-making, which are thought to be vital to performance in invasion sports such as AF (Wisbey et al., 2010). Perceptual-cognitive skills are very hard to capture in their entirety in a field setting, so researchers have developed ways to capture and measure their components in a laboratory setting using video-based simulations. It has been suggested that a multidimensional approach is needed to gain a more comprehensive understanding of the various components of perceptual-cognitive skill (Helsen & Starkes, 1999). For example, a more effective method would be to develop a battery of sub-tests, which are all completed by an elite group of athletes. To investigate perceptual-cognitive skills among elite AF players, a test battery including an examination of pattern recall (e.g., whether players are able to remember the positioning of other players), ruck cue utilization (e.g., whether players can read vital cues at a center bounce contest), and decision-making with the ball (e.g., whether players can choose the best option in a given situation) would be ideal to provide an overall analysis of anticipation and decision-making relative to the demands of the sport.

This exploratory study compares differences in perceptual cognitive skill within an elite (full-time professional) group of performers. Studies on perceptual-cognitive skill in sport have not explicitly compared elite performers with one another, usually using a comparison with novice or lower level participants. Studies have also generally investigated only one component of perceptual-cognitive skill. Using a video-based test battery, which explores a number of components of perceptual-cognitive skill, this exploratory study investigated whether there are significant differences in test accuracy between: a) a *highly skilled* and *skilled* decision-making group of elite (full-time professional) AF players; b) *midfield* players and *key position* players; and, c) *experienced* players and *inexperienced* players.

Methods

Participants

Forty-six elite (full-time professional) male AF players from one team (*M* age = 22.0, *SD* = 3.4 years) participated. Ethical approval was obtained from the Deakin University Human Ethics Advisory Group and written informed consent was then obtained from each participant. Seven expert coaches rated player in-game decision-making skill by scoring each player out of 10 for the following: a) with the ball (ICC = 0.94), and b) when the opposition has the ball (ICC = 0.89). Each coach was instructed to rate each player against the AFL competition, with a 10 meaning the top 10th percentile, down to a 1 being the bottom 10th percentile. Average scores (out of 10) for each of the two decision-making variables were compared (r (44)= 0.88, $p < 0.01$), and due to the high correlation, scores were then combined to produce an average score out of 20. The top 23 players then formed the highly skilled group (*M* score = 14.04, SD = 1.62), and the bottom 23 made up the skilled group (*M* score = 9.27, SD = 2.04). The highly skilled group had a mean age of 22.9 (SD = 3.6 years) and the skilled group a mean age of 21.1 (SD = 2.9 years).

Participants were also stratified in terms of playing position, based on the role they have played in the majority of their games. Twenty were classified as *midfield* players (*M* age = 21.8, *SD* = 3.5 years), and 26 were *key position* players (*M* age = 22.2, *SD* = 3.3 years). Finally, the players were classified in terms of the number of games played at AFL level. Players were divided into two groups at the 50th percentile. The *experienced* group consisted of the 23 players who had played the most AFL games (*M* age = 24.4, *SD* = 3.0 years), which ranged from 25-301 games. The *inexperienced* group consisted of the 23 players who had played the least AFL games (*M* age = 19.6, *SD* = 1.6 years), which ranged from 0-24 games.

Video-based test and procedure

A video-based test consisting of three sub-tests: pattern recall, ruck cue utilization, and decision-making with the ball, was developed. Each sub-test involved a number of short video clips taken from Australian Football League (AFL) games. The sub-tests utilized a third-person perspective (Craig, 2013). The third-person perspective has been used extensively in research on perceptual cognitive skills in sport (Larkin, Mesagno, Spittle, & Berry, 2015; Mann, Williams, Ward, & Janelle, 2007), including with AF players (Larkin, Berry, Dawson, & Lay, 2011; Lorains, Ball, & MacMahon, 2013) and AF umpires (Larkin, Mesagno, Berry, & Spittle, 2014; Larkin, Mesagno, Berry, Spittle, & Harvey, 2017). Previous studies comparing first and third person aerial perspectives in water polo and soccer have also demonstrated higher decision-making accuracy for the third person perspective (Farrow, 2007; Mann, Farrow, Shuttleworth, & Hopwood, 2009).

The development of each sub-test was done in four main stages: (a) finding and editing a large number of individual video clips that addressed key criteria; (b) content validity and scoring system established by expert coaches; (c) clip/item analysis to investigate the difficulty and discrimination of each clip (Miller, 2006); and, (d) test-retest reliability of each sub-test. Figure 1 shows the development and attributes of each sub-test.

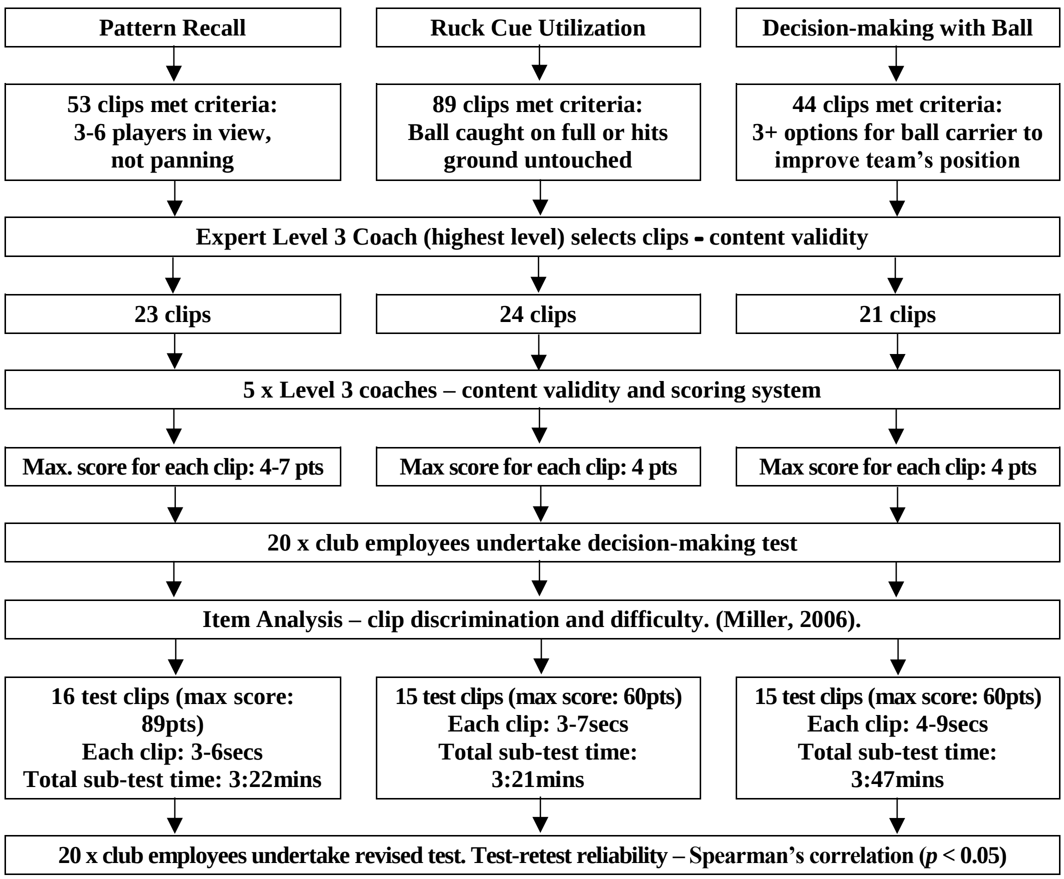


Figure 1. Development of the decision-making test.

Standardized instructions were presented on the screen and read out by the tester at the beginning of each sub-test. To familiarize participants with the test protocols, three practice clips per sub-test were performed, whereby participants could ask questions. The test clips then followed and were structured in the following way: a) the clip number; b) the short passage of play; c) the edited still shot of the final frame (with some players removed); and d) the answer slide (see Figures 2, 3, and 4). The order of presentation of the clips was determined via random selection. After each clip was presented, participants were required to respond by drawing their answer, using crosses ("X"), onto the screen. The video was paused to allow enough time for responses to be recorded (maximum of 5 seconds), after which the video was resumed to display a coded answer screen, during which the tester manually recorded the score next to the applicable clip number and the participant erased their crosses prior to the next clip. No feedback about scoring or coding was given to participants during or after the test. Each sub-test took between 7 and 8 minutes to complete. Each participant individually performed the 3 sub-tests in a random order, during the in-season over a 4-week period.

Data analysis

A MANOVA was the preferred choice of analysis, but the assumption for multicollinearity was violated (Allen & Bennett, 2008). Therefore, a series of independent samples *t*-tests were used, with Bonferroni correction ($p < 0.0125$) applied to reduce Type I error. For each group and data set, tests of normality were carried out (Allen & Bennett, 2008). Univariate normality was violated for the decision-making with the ball sub-test in all 3 sub groups, so Mann-Whitney U tests were used. When interpreting results, an *r*-value of 0.10 represents a small effect size, 0.30 represents a medium effect size, and 0.50 represents a large effect size (Miller, 2006). All statistical analysis was performed using SPSS V22.0.

(a)

(b)

(c)

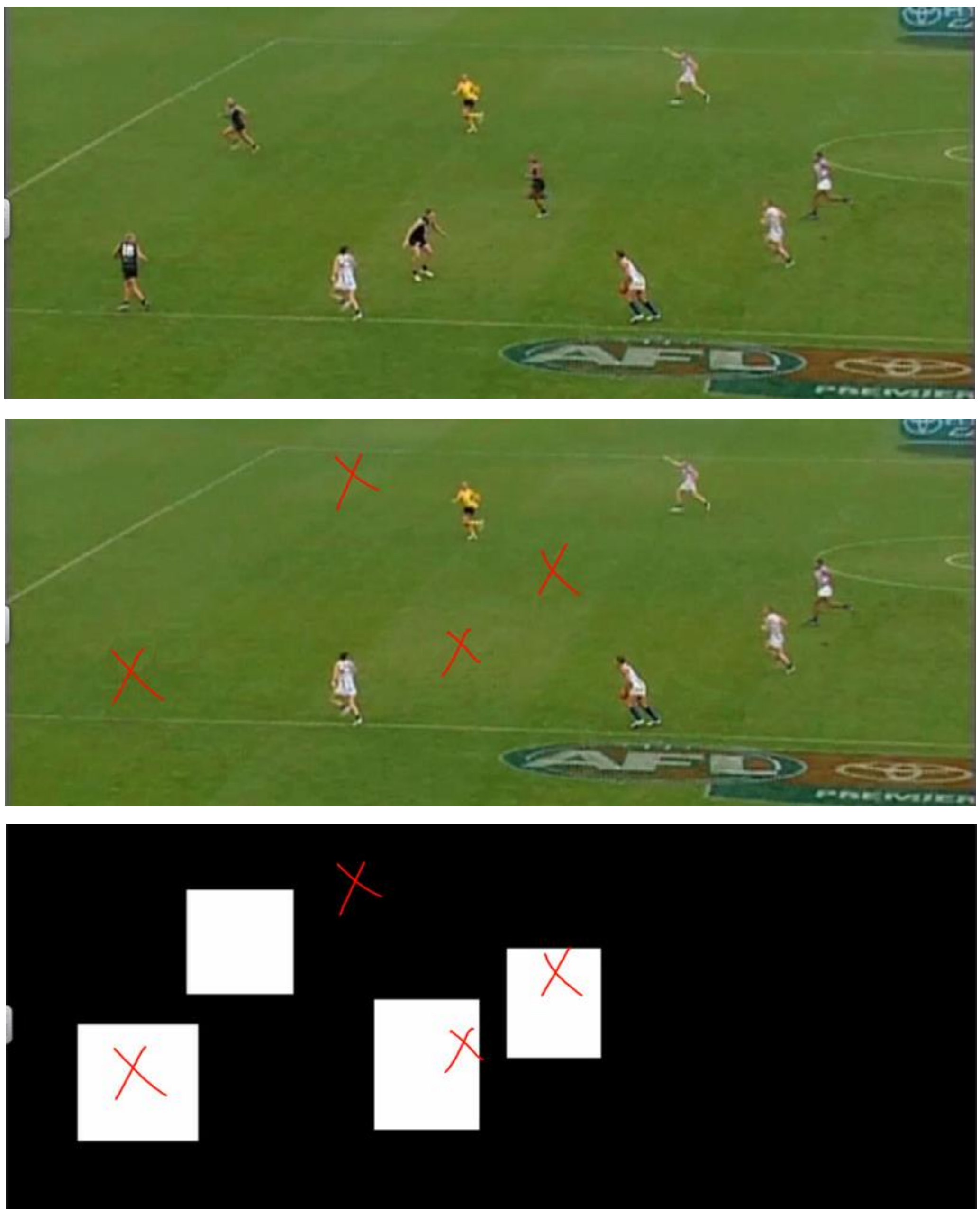


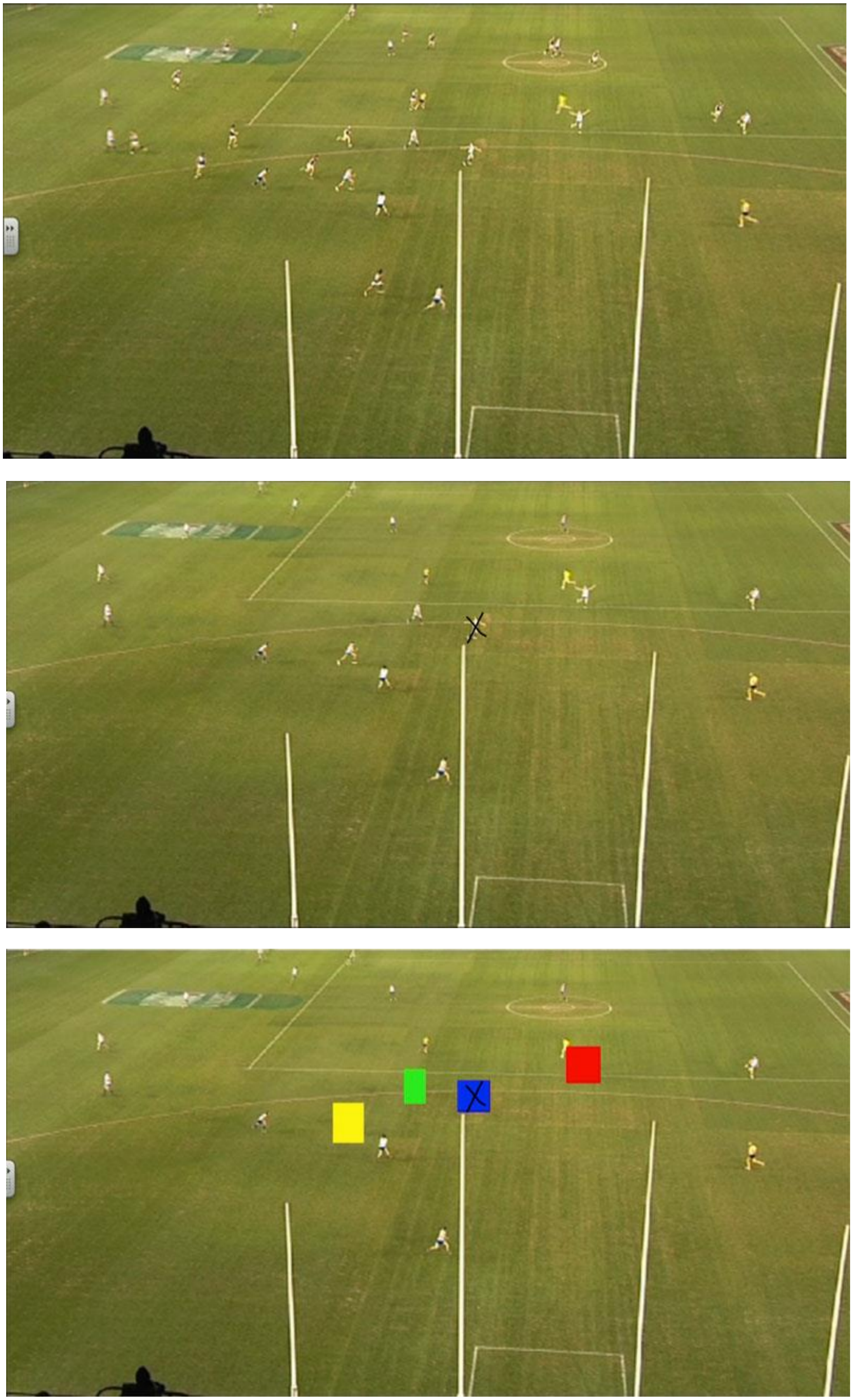
Figure 2. Video stills showing (a) the final frame of the clip, (b) the occluded image, and (c) the answer still image of pattern recall.

(a)

(b)

(c)

Figure 3. Video stills showing (a) the final frame of the clip, (b) the occluded image, and (c) the answer still image of ruck cue utilization.



(a)

(b)

(c)

Figure 4. Video stills showing (a) the final frame of the clip, (b) the occluded image, and (c) the answer still image of decision-making with the ball.

Results

Once all players had individually completed the test, comparison groups were established based on skill level, player position, and playing experience. While exploratory in nature, video-based test performance was then compared between the different groups (see Table 1). Each sub-test had a total score that players could achieve (see Figure 1), meaning the maximum score that a participant could achieve on the decision-making test was 209 (total test score). Individual scores ranged from a low of 104 to a high of 157. Scores were calculated based on the established scoring system, which allocated up to 4 points per clip for the ruck cue utilization and the decision-making with the ball sub-tests (the 'better' the decision, the higher the score). In the pattern recall sub-test, each clip was scored between 4 to 7 points, based on the number of crosses that were correct.

There was a medium effect size, although not significant, for the *highly skilled* players performing better on the test than the *skilled* players. A small effect size was found for the ruck cue utilization sub-test and a significant difference between the *highly skilled* group and the *skilled* group on the decision-making with the ball sub-test. There were no significant differences between neither the *key position* players and the *midfield* players, nor the *experienced* players and the *inexperienced* players, for total test score or any of the sub-tests.

Table 1. Test scores by groups

	GROUP							95% CI of Mean Difference	
Coach-rated skill groups	**Highly Skilled**		**Skilled**						
	M	*SD*	*M*	*SD*	*t*	*p*	*r*	*Lower*	*Upper*
Total Test Score	133.0	10.0	126.0	12.3	2.11	.04	.30	.30	13.62
Pattern recall	58.1	7.8	57.7	8.3	.17	.87	.02	-4.40	5.18
Ruck Cue Utilization	36.2	4.7	33.6	4.6	1.88	.07	.27	-.19	5.32
Decision-Making with Ball	38.7	3.7	34.7	5.5	-2.59*	.01**	.38	1.21	6.80
Positional groups	**Midfield**		**Key Position**						
	M	*SD*	*M*	*SD*	*t*	*p*	*r*	*Lower*	*Upper*
Total Test Score	128.1	11.0	130.7	12.2	-.78	.44	.12	-9.69	4.31
Pattern recall	55.9	8.4	59.5	7.4	-1.55	.13	.23	-8.32	1.10
Ruck Cue Utilization	35.9	4.9	34.1	4.6	1.27	.21	.19	-1.05	4.62
Decision-Making with Ball	36.3	4.3	37.1	5.7	-.88*	.38	.13	-3.93	2.19
Game experience groups	**Experienced**		**Inexperienced**						
	M	*SD*	*M*	*SD*	*t*	*p*	*r*	*Lower*	*Upper*
Total Test Score	129.4	11.4	129.5	12.1	-.03	.98	.13	-7.07	6.90
Pattern recall	56.7	7.9	59.0	8.0	-.98	.33	.15	-7.01	2.43
Ruck Cue Utilization	35.2	4.7	34.6	4.9	.46	.65	.07	-2.21	3.51
Decision-Making with Ball	37.5	4.5	35.9	5.6	-.89*	.37	.00	-1.44	4.57

Note. * Denotes reporting of a z-score due to use of Mann-Whitney *U* test; ** significant at $p < 0.0125$

Discussion

The aim of this exploratory study was to compare perceptual-cognitive performance, using a video-based test, within elite (full-time professional) Australian football (AF) players. The test measured three different components of anticipation and decision-making skill: pattern recall, ruck cue utilization, and decision-making with the ball. The *highly skilled* group did not perform significantly better than the *skilled* group on the overall score for the video-based test (r = 0.30, p = 0.04), however a medium effect size was found (Miller, 2006). This was found to be mostly the result of significantly higher scores being obtained on the decision-making with the ball sub-test with a medium effect size (r (44) = 0.38, p = 0.01), and the ruck cue utilization sub-test, which had a small effect size (r (44) = 0.27, p = 0.07). There was no difference between the groups for pattern recall.

Expert groups from a range of invasion sports have been found to perform better than novice groups on video-based tests for tasks such as pattern recall (Williams & Davids, 1995), advance cue utilization (Ward & Williams, 2003; Jackson et al., 2006), and strategic decision-making (Vaeyens et al., 2007; Mann et al., 2007). The current study used athletes from within the same team and level of competition, in contrast to the traditional expert-novice paradigm, whereby athletes with wide varying experience and skill having played at different levels of competition are compared (Williams & Ford, 2008; Tenenbaum, 2003), which could explain some differences in findings. It was expected that the players with the best decision-making skills would score higher than the players with inferior decision-making skills based on evidence suggesting that video-based anticipation and decision-making tests are able to discriminate between groups from within elite level AF (Berry, Abernethy, & Côté, 2004). The majority of research investigating differences in perceptual-cognitive skill between groups has utilized the expert-novice paradigm, whereby athletes with varying experience, who have played at different levels of competition, are compared. The expert groups from a range of invasion sports have been found to perform better on video-based tests than the novice groups for tasks such as pattern recall (Allard & Burnett, 1985; Williams & Davids, 1995), advance cue utilization (Jackson, Warren, & Abernethy, 2006; Ward & Williams, 2003; Williams & Davids, 1998; Williams, Davids, Burwitz, & J. Williams, 1994), and strategic decision-making (Helsen & Starkes, 1999; Vaeyens, Lenoir, Williams, Mazyn, & Philippaerts, 2007).

However, there was some support for the findings of Mann et al. (2007), who reported in a meta-analysis of expert-novice studies of perceptual-cognitive skill, that effect sizes for group differences for response accuracy was largest for decision-making tasks (r = 0.42), then anticipation tasks (r = 0.36), while recall tasks produced a smaller effect size (r = 0.17). In line with the current study, this suggests that the most profound differences between skilled and less skilled performers occur in the more complex tasks, such as decision-making, which involve elements of recall, recognition, and anticipation (Berry et al., 2008). Decision-making tasks might produce the biggest differences because they are more highly skilled activities than, for example, pattern recall or cue utilization. A recent study by Brenton and Muller (2016) reported that video-based temporal occlusion with a motor response discriminated anticipation in skilled cricket players, suggesting that specificity and complexity may be important for fine-grained distinction in skilled samples.

The decision-making with the ball sub-test was able to discriminate between the groups, not only because it was the most complex of the three sub-tests, but also because it was the most "football-specific." To succeed at the task, players were required to use both declarative and contextual knowledge, which are thought to be important components of skilled performance (Williams & Davids, 1995). More information was presented in this test (e.g., up to 36 players in shot) and due to the complex patterns of play, pattern recognition skill was also required.

While the ruck cue utilization sub-test still requires the use of declarative and contextual knowledge, the task represented an isolated and highly structured aspect of AF, the center bounce, in which fewer players are directly involved in the contest. This means that the sub-test is less complex and isolates the concept of advance cue utilization, which could make it less likely to discriminate between the *highly skilled* and *skilled* groups. No significant difference was found between groups in the current study; however, there was a small effect size. The sample may have been too small to show significant differences, which is a common limitation of using an elite sample. According to Hopkins, Hawley, and Burke (1999), when interpreting results regarding athletes, effect sizes may actually represent differences that are worthwhile to elite athletes. In a competitive setting, a small difference in performance could affect the outcome of a match or a race. Individual trial analysis for each participant may be a future research direction for studies exploring differences within skilled groups (Muller et al., 2015).

The least complex and football-specific sub-test, pattern recall, required minimal use of declarative or contextual knowledge. It simply tested visual memory using general play football scenarios, which could explain why no significant differences were found on that task. It is possible that the more representative the task design, the bigger the difference that will be found between groups of varying skill level (Larkin, Mesagno, Spittle, & Berry, 2015). While field tests of perceptual-cognitive skill produce the largest effect size for response accuracy when comparing experts and novices, realistic video-based tests are the next best method (Mann et al., 2007).

No significant differences in test performance were found for total test scores, or sub-test scores, between the *midfield* players and the *key position* players. While Williams et al (2008) found defensive soccer players to be more accurate than offensive soccer players on a video-based anticipation task, the current study grouped the players differently, due to the strategies of AF. *Midfield* players have a major role to play at stoppages in AF, such as center bounces. Key defenders and key attackers, on the other hand, do not attend stoppages and are often interchangeable; hence, these players were grouped together into *key position* players. While the ruck cue utilization sub-test required the use of declarative and contextual knowledge, the task represented an isolated and highly structured aspect of AF, the center bounce, in which just 8 players (4 from each team) are directly involved in the contest. As the midfield group spend more time with video feedback and practicing center bounces, this result was unexpected. However, players often change positions and play a variety of roles, sometimes within the same game and from week to week. When training for AF, the *midfield* players spend a significant amount of time practicing stoppages. Although the *key position* players do not have the same focus for their training, they observe, watch vision, and listen to feedback regarding the stoppages. Observational learning can result in significant knowledge being learned from peers (Breed & Spittle, 2011). Because the video-based test examined only perception and not action, it is possible that no differences were found between the groups, because players from the two groups were able to perceive situations in a similar way without having to perform the physical components of the skill, such as the timing and application of bodywork on their opponents.

No significant differences were found between test scores for the *experienced* and *inexperienced* players, when separated into two groups at the 50th percentile (0-24 games and 25+ games). It is believed that perceptual-cognitive skills improve with practice and experience (Williams & Ericsson, 2005). Researchers have often stratified groups in terms of experience using the expert-novice paradigm, finding that experts consistently perform better than novices on perceptual-cognitive tasks (Williams & Ford, 2008). The experience difference between the groups, however, is often many years at different playing levels. This study was novel, in that the groups in this study were compared based on how many games they had played at the elite AFL level and on the assumption that an increased number of games may relate to increased declarative and contextual knowledge, rather than overall experience at a variety of levels of competition. It appears that the number of games played at AFL level does not influence performance on a video-based perceptual-cognitive test. Given that AF is a multifaceted game, it appears that the *experienced* players may be able to play at the highest level due to strengths in areas of the game other than perceptual-cognitive expertise.

In AF, perceptual-cognitive skills, such as anticipation and decision-making, are believed to be vital to performance (Berry, Abernethy, & Côté, 2004). The current exploratory study aimed to develop and administer a multidimensional video-based test of perceptual-cognitive skill to examine whether there were performance differences within a similar sample of elite AF players. Given the findings in this exploratory study, it is suggested that in the future perceptual-cognitive skill tests in invasion sports should continue to present a range of tasks to identify the strengths and weaknesses in the decision-making process. Employing a multidimensional approach in the current study meant that the results for three different components of perceptual-cognitive skill could be compared, leading to the finding that the most realistic and complex sub-test produced the largest differences between groups. The approach used in the current study was novel and comprehensive, in that performance on a range of components of perceptual-cognitive skill were tested among a similar group of AF players. Rather than employing the expert-novice paradigm that has most commonly been used in the past, within-group differences were examined for an elite sample, stratified for decision-making level, player position, and AFL-level playing experience. This exploratory study provides a foundation for future research, which is required in order to increase the understanding of the importance of perceptual-cognitive skill in invasion sports and to compare skills within similar groups.

Conclusion

The current study examined the perceptual-cognitive skill of elite (full-time professional) AF players using video-based tests. No significant differences were found for the overall test scores between groups stratified by skill level, player position, or playing experience. However, the *highly skilled* group scored significantly higher than the *skilled* group on a decision-making with-the-ball sub-test that required participants to choose the best option in a range of complex scenarios. For the less complex sub-tests, pattern recall and ruck cue utilization, no significant differences were found between groups. This suggests that the more closely the test resembles the real-life scenario, the more likely it is to discriminate between groups of different abilities at an elite (full-time professional) level.

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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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