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Decision reinvestment, pattern recall and decision making in rugby union

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ABSTRACT

The ability to recognise patterns of play and then respond rapidly and appropriately under pressure is considered fundamental for successful performance in rugby. Decision reinvestment, a predisposition to consciously process decision-making, has been shown to negatively affect performance under pressure and may play a role in pattern recognition. Study 1 assessed the role of decision reinvestment in pattern recall speed and accuracy. Professional rugby players (N = 57) viewed still images of structured rugby scenarios for 5 s before occlusion. Participants then recalled the positions of six specified players from each scenario as quickly and as accurately as possible on a blank template. Propensity for conscious processing of decision-making was assessed using the Decision Specific Reinvestment Scale, and examined with respect to recall accuracy and decision time. Results suggested that higher scores were associated with slower recall speed and poorer accuracy. Study 2 tested whether the findings in Study 1 were due to memory decay associated with slower decision processes. Skilled rugby players (N = 41) completed the same procedure as Study 1; however, following occlusion they either recalled the six players in any order (Whole Report) or recalled one half of the players (specified) before the other half (Constrained Report). Recall of the second half of the players was found to be significantly less accurate than the first half, in both the Whole and Constrained Report conditions. This suggests that increased time between encoding and retrieval of visual information leads to a decay in memory of players' positioning.

1. Introduction

Effective decision-making is crucial in sport; so much so, that McMorris (2014) and Royal et al. (2006) suggested that the capability to make quick, accurate decisions is as important as skill execution. The ability to recognise patterns, a key determinant of appropriate decision-making, has been identified as fundamental for success in rugby (Hendricks, 2012) and has also been shown to predict performance in an anticipation task (Farrow, McCrae, Gross, & Abernethy, 2010). It is also believed that understanding the location of teammates and opponents is a key process in making appropriate decisions, such as to whom to pass and when (Gorman, Abernethy, & Farrow, 2012). Pattern recall tasks have been developed to test this perceptual-cognitive skill and have been used in sports such as basketball (Gorman, Abernethy, & Farrow, 2011) and rugby union (Farrow et al., 2010). Pattern recall procedures require participants to indicate where items, objects or individuals were positioned in previously viewed stimuli. Chase and Simon (1973), for example, famously used a 5 s recall task to show that expert chess players were superior to novices when recalling the positions of chess pieces on a board if the positions were consistent with an actual game, but not if the positions were random.

Conscious processing of decision and movement skills has been shown to be detrimental for performance under pressure. For example, Smeeton, Williams, Hodges, and Ward (2005) investigated the effect of consciousness on perceptual-cognitive skills. Participants were required to make anticipatory judgments about the direction of an opponent's tennis shot with the assistance of either explicit (highly conscious) or implicit (unconscious) instructions. For example, explicit instructions for detecting a drop shot included statements, such as '*look at the player's hips and shoulders*, see how little they rotate in comparison to other shots' (p. 102), whereas, implicit instructions only included the text in italics. The researchers found that only participants who received explicit instructions suffered performance decrements under pressure, demonstrating the damaging effects of relying on conscious, explicit knowledge when executing perceptual-cognitive skills under pressure.

Reinvestment is a personality trait associated with conscious monitoring and control of movement, which has been shown to play a role in decision-making and execution of motor skills. However, to date the propensity for reinvestment has not been investigated in rugby union or in relation to pattern recall ability. Movement specific reinvestment (Masters, 1992), explains an individual's propensity to draw upon (and reinvest) previously acquired explicit, rule-based knowledge to consciously control movements. Research in the motor domain has generally shown that individuals who reinvest highly are more likely to experience skill breakdown under pressure (e.g., Chell, Graydon,

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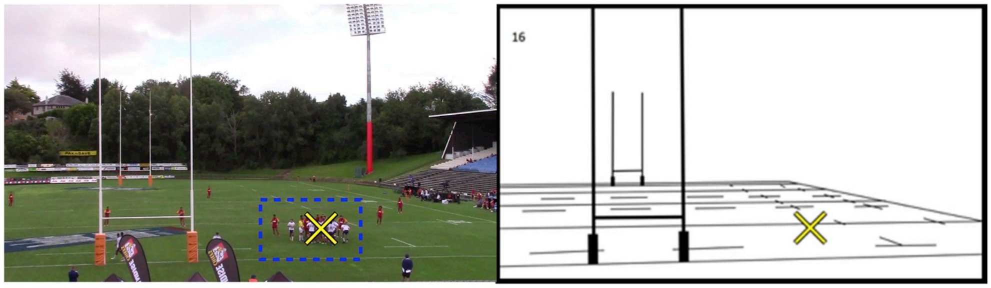

Fig. 1. Test stimuli (left) recall sheet (right).

Crowley, & Child, 2003; Jackson, Ashford, & Norsworthy, 2006). It has been suggested that this occurs because reinvestment causes de-automatization of previously automatized skills (Masters, 1992; Masters & Maxwell, 2008). Automated or proceduralised skills tend to involve unconscious processes, which are faster, require less effort and are more efficient than conscious processes (Hasher & Zacks, 1979; Logan, 1988; Shiffrin & Schneider, 1977).

The Decision Specific Reinvestment Scale (DSRS), developed by Kinrade, Jackson, Ashford, and Bishop (2010), can be used to assess an individual's predisposition for conscious processing of decisions. The Scale assesses decision reinvestment (an individual's propensity to consciously monitor the processes involved in making a decision), and decision rumination (an individual's propensity to focus on negative evaluation of previous poor decisions). Evidence has suggested that individuals who score highly on the DSRS perform worse, and make slower decisions, under pressure in sports such as basketball (Kinrade, Jackson, & Ashford, 2015), netball (Jackson, Kinrade, Hicks, & Wills, 2013) and korfball (Kinrade et al., 2010). Additionally, higher DSRS scores have also been associated with impaired decision making and bias under pressure in netball umpires (Burnett, Bishop, Ashford, Williams, & Kinrade, 2017) and football referees (Poolton, Siu, & Masters, 2011).

Masters (1992) suggested that these performance decrements occur because reinvestment leads to slow step-by-step processing, similar to processing during the early stages of learning (see also Beilock, Carr, MacMahon, & Starkes, 2002). Consequently, we hypothesised that individuals with a high propensity for decision specific reinvestment would display slower and/or less accurate recall.

In Study 1, professional rugby players completed a rugby specific pattern recall task. Still images of structured rugby patterns were displayed for 5 s before occlusion (c.f. Chase & Simon, 1973) and participants were required to recall the positions of six specified opposition players on a blank template. Decision specific reinvestment scores provide the independent variable, with recall speed and recall accuracy forming the dependent variables.

2. Study 1

2.1. Method

2.1.1. Participants

Fifty-seven elite male rugby union players (age 22.63 ± 3.14 years) with an average of 3.54 ± 2.6 years of professional experience were recruited to take part in the study. The sample size was based on calculations using G*Power 3.1, which showed that 52 participants provided sufficient power (0.8) to detect at least medium-to-large effects ($p = .33$). These calculations were performed by adopting an alpha of .05 and non-sphericity correction of 1. Players could be categorised as Backs (N = 28) or Forwards (N = 29) and were recruited from the top two leagues in New Zealand. All provided informed consent prior to involvement.

2.1.2. Test images

Still images (N = 55) were collected, via screenshots of a video feed, from a match between two Super Rugby under 20 teams. Static, as opposed to dynamic, images were adopted on the basis of research by Gorman et al. (2012), which suggested that there was no significant difference in experts' recall accuracy when comparing static against dynamic stimuli. Stimuli were collected from a less well-known game to reduce the participants' familiarity with styles of play and inhibit the ability to identify individuals within the images. The camera (Canon HFR506, Tokyo) filmed the match from the end of the pitch (perpendicular to the try line), 5 m above ground level. This provided an enhanced viewing angle that was more ecologically valid from a player perspective than a side-on viewing angle. The elevated viewing angle aided participants to distinguish depth (as suggested by van Maarseveen, Oudejans, & Savelsbergh, 2015). The 55 images were rated by two world-renowned coaches on a Likert scale from 1 to 10 based on level of structure of the team playing towards the camera; 1 represented highly unstructured, whereas 10 represented highly structured. Only structured images that were scored 8 or above by both coaches were included in the test protocol. The final test protocol contained 20 images.

2.1.3. Test procedure

Participants' viewed the still image of a rugby union scenario presented by a projector (Panasonic, CW230, Japan). The still image was presented for 5 s before it was occluded. Once the image was occluded, participants were required to recall the location of specific individuals from the team that was playing towards the camera as accurately as possible. In each image, there were six player positions to recall. Participants were instructed to enter six positions on each recall sheet – even if they were unsure of a player's positioning. Additional players (other than the six required) were identified by a blue box that signalled to participants that they did not need to be recalled (see Fig. 1). This ensured that the number of players recalled was equivalent across all stimuli.

2.1.4. Recall procedure

To recall the location of the players in each still image, participants sat at a comfortable distance from a MacBook Pro (Apple, OS X 10.11.6, California) running an open Microsoft Excel document. The sheets in the document contained edited templates of the previously viewed still image - with only the pitch markings, post location and reference point displayed (Fig. 1 - reference point is the yellow 'X'). This was defined as the blank template. The reference point was overlaid on each image to signify the area of the pitch where the play took place and was in the same position on the recall sheet as the still image. In all cases, the reference point was a conspicuous feature of the image, such as the location of the ball, scrum or ruck. Cells (N = 19,176; 188 columns x 102 rows) constituting a 5 pixel × 5 pixel area overlaid the template. Participants were required to enter the letter X in the cell where they believed the six players were located, as quickly and accurately as possible. For consistency, participants were instructed to use the cell where the player's feet were touching the ground. Participants could

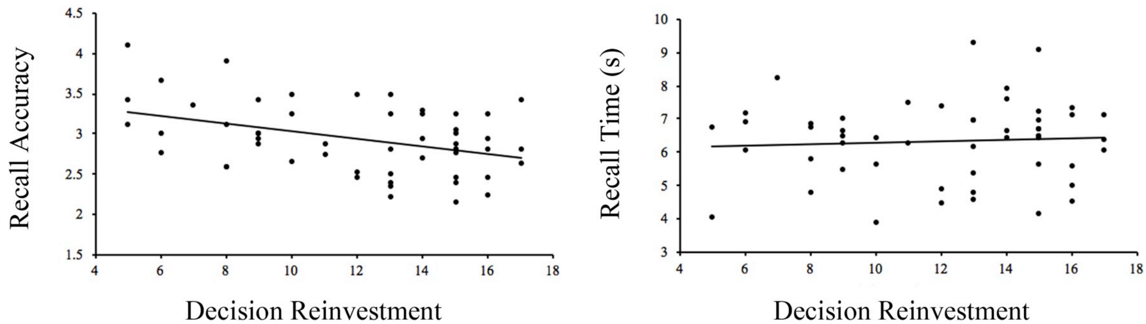

Fig. 2. Correlations between decision reinvestment, recall accuracy and recall time (s).

change the location of their chosen positions by deleting and re-positioning their X's within the cells. Those taking part were informed that the speed and accuracy of their responses was being recorded for the experimenter's consideration only.

To calculate the distance between the coordinates of the participant's chosen locations (x1 and y1) and the actual locations of the players (x2 and y2). Pythagoras' Theorem ($\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$) was used to determine these distances.

Upon cessation of the recall procedure, participants completed the DSRS by rating how statements (N = 13) characterized their on-field decision-making, on a Likert scale that ranged from 0 (extremely uncharacteristic) to 4 (extremely characteristic). A global score was calculated by summing scores from all 13 statements. A decision reinvestment score was calculated by summing the 6 statements measuring this factor, e.g. "I'm always trying to figure out how I make decisions" and a rumination score was calculated by summing the 7 statements relating to this factor, e.g. "I remember poor decisions I make for a long time afterwards".

2.1.5. Data analysis

To develop an accuracy scoring system for the pattern recall task, a 6-cell radius around the actual location of each player was established. If participants indicated a location in a cell within the radius then recall was deemed to be accurate. Furthermore, if two chosen locations fell within the 6 cell radius of an actual location only one chosen location was allocated to the actual location with the closest distance deemed successful. A 6-cell radius was considered sensitive enough to uncover differences between participants following pilot work.

The number of correctly indicated locations was summed to create a score out of a possible 6 (accuracy score). This analysis method differed from the majority of previous pattern recall studies, with the exception of Allard, Graham, and Paarsalu (1980) and Abernethy, Neal, and Koning (1994). Most pattern recall tasks utilize the average absolute distances of chosen locations from actual locations of players with the smallest possible combination of distances chosen. In pilot testing it was discovered that there were common miscalculations in which chosen locations were not assigned to the appropriate actual location and as such results were inaccurate. This method of analysis was considered to best measure the perceptual-cognitive skills required in actual performance. Greenwood (2015) highlighted the importance of recognizing simple but crucial patterns to create space in attack and thus minimise space in defence. Such patterns include occasions when the attacking team has an additional player compared to the defensive team (e.g., 4 attacking players against 3 defending players) or when there are larger gaps between certain defenders. This suggests that understanding the general pattern – as measured using the scoring method adopted here – is more appropriate than knowing exactly where each individual player is positioned.

To calculate recall times, screen recordings were made of each participant's laptop during their recall procedure using QuickTime Player (Apple, Version 10.4, California). A tone sounded at the point of occlusion, signifying the start of recall. Software (iMovie - Apple, Version 10.1.6, California) was used to measure the time between the tone and the moment at which the last player's position was entered. An average of each participant's recall times was calculated for analysis.

Statistical tests were conducted in SPSS (Version 24, IBM, UK). As a consequence of violations of normality, six Spearman's Rho correlations were performed to test the relationship between the independent variables (Global Reinvestment, Decision Reinvestment and Rumination) and the dependent variables (Recall Accuracy and Recall Time).

3. Results

The average Recall Accuracy of participants was 2.9 out of 6 (SD = 0.42, range = 1.9) and the average Recall Time was 6.39 s (SD = 1.22, range = 5.4 s). Furthermore, there were no significant differences in Recall Accuracy or Recall Time between the stimuli ($p > .05$). Additionally, recall accuracy did not differ by individual players in each stimulus ($p > .05$). Spearman's Rho coefficients revealed that there was no association between Global Reinvestment and Recall Accuracy ($r = -0.225$, $p = .106$). Global Reinvestment was, however, significantly positively associated with Recall Time ($r = 0.366$, $p = .007$), suggesting that higher scores were related to slower responses.

Follow up Spearman's Rho coefficients were computed to examine the two factors of the DSRS (Decision Reinvestment and Rumination) separately. A significant negative association was identified between Decision Reinvestment and Recall Accuracy ($r = -.338$, $p = .013$), with higher decision reinvestment scores associated with poorer recall accuracy. Decision Reinvestment scores were also positively associated with Recall Time ($r = 0.289$, $p = .036$), with higher scores on the scale associated with slower recall (see Fig. 2). No significant correlations were found between Rumination, Recall Accuracy ($r = -0.003$, $p = .983$) or Recall Time ($r = 0.181$, $p = .194$).

4. Discussion

Pattern recall has been shown to be an important facet of decision-making and anticipation in sport. However, the relationship between decision specific reinvestment - a personality trait that that has been linked to poor decision-making - and pattern recall has not been investigated to date. Therefore, the current investigation tried to understand the association between decision specific reinvestment and pattern recall ability.

The results suggested that elite players with a higher propensity to consciously process their decision-making took longer to recall patterns and also displayed inferior recall accuracy, compared to players with a lower propensity to consciously process their decision-making. As mentioned previously, unconscious processes are more efficient

(Hasher & Zacks, 1979; Logan, 1988; Shiffrin & Schneider, 1977) and reinvestment may lead to step-by-step processing (similar to in the early stages of learning) which slows recall (Masters, 1992). Therefore, a simple explanation for high reinvestors' slower recall is that their reliance on conscious processing extended the duration required to process a decision.

Previous research has shown that experts are able to encode information from patterns, even without conscious attention (Gorman, Abernethy, & Farrow, 2017; Gorman et al., 2012; Memmert, 2006). Gorman et al (2017) suggested that experts are able to do this as they have most likely learned to process patterns 'implicitly' – without awareness of what has been learnt (e.g., Masters, 1992; Sun, Merrill, & Peterson, 2001). As mentioned previously, reinvestment involves utilization of previously acquired explicit knowledge when performing tasks. Therefore, as high reinvestors tend to rely more on explicit processes than, implicit processes, they may struggle to encode information from patterns when conscious attention (necessary for explicit processing) is occupied elsewhere. This could lead to difficulty learning these patterns during performance. A key difference between these findings and previous studies of decision reinvestment and decision making, is the lack of an effect of rumination (Burnett et al., 2017; Poolton et al., 2011). However, participants received no feedback about their performance between trials, which may have reduced rumination about the previous stimuli.

The results of this study can also be explained using theories of forgetting. For example, Decay Theory (Brown, 1958) suggests that learned material leaves a trace, or impression, in the brain that recedes and eventually disappears unless the material is practiced and used. Classic research by Sperling (1960) showed that memory for visual information is substantial but decays extremely rapidly. Sperling's (1960) work focused on iconic memory, which has typically been described as incredibly short (< 1000 ms) and acts as a buffer before information reaches short term memory. The very short duration of iconic memory does not encapsulate the longer recall times recorded in the current investigation (ranging from 4030 to 9306 ms); however, more recent research by Portrat, Barrouillet, and Camos (2008) has suggested that Decay Theory can be used to explain forgetting in working memory, which is a cognitive mechanism "capable of retaining a small amount of information in an active state for use in ongoing tasks" (Furley & Memmert, 2015, p.1). Consequently, high decision reinvesters in Study 1 who took longer to recall patterns may have displayed poorer recall accuracy because their memory trace of players' positions had more opportunity to decay.

5. Study 2

Sperling (1960) adopted a partial report procedure to examine memory decay, in which participants viewed a random array of letters and/or numbers for a short duration (50 ms), following which they attempted to recall the stimuli. In a whole report condition, participants were required to recall all of the elements in the correct order. In a partial report condition, participants were only required to recall a portion of the elements, such as the bottom row. Results showed that recall in the whole report condition was approximately 35% compared to approximately 75% in the partial report condition. Importantly, it did not matter which portion of the array was recalled as this information was only revealed upon occlusion. The superior recall in the partial report condition suggests that all of the information from the stimuli is initially available to the individual; however, the reduced recall accuracy in the whole report condition suggests it decays during recall.

In Study 2, we adopted a methodology similar to Sperling's (1960) partial report procedure to test for memory decay during our pattern recall task. As in Study 1, participants were required to recall the position of six players from previously viewed stimuli. However, in a whole report condition participants recalled the player positions in any order, whereas in a constrained report[1] condition participants were required to recall a specified half of the players first before recalling the remainder. It was hypothesised that the positions of the first three players recalled would be significantly more accurate than the second three players, in both the whole report and constrained report conditions. Participants were only informed about which players to recall (whole or constrained) when the clip was occluded. Therefore, the absence of a significant difference in recall accuracy between the two specified halves recalled first (i.e., left vs right) would suggest that the positional information of all players is available initially but decays.

6. Method

6.1. Participants

Forty-one highly skilled male rugby players (age 17.07 ± 0.64 years) with an average of 9.17 ± 2.76 years playing experience were recruited to take part in the study. G*Power 3.1 calculations showed that 36 participants provided sufficient power (0.8) to detect at least medium-to-large effects (p = .33), when adopting an alpha of .05 and non-sphericity correction of 1. The players recruited did not take part in Study 1 and were part of a Super Rugby team's Under 18 Squad. All participants provided informed consent before completing the procedure.

6.2. Test images

Thirteen of the 20 images used in Study 1 were edited and used in Study 2. These stimuli were edited to include a line that vertically dissected the image so that, of the six players to be recalled, three appeared on either side of the line (Fig. 3).

6.3. Recall procedure

The recall procedure mimicked Study 1 save for minor alterations. Initially, rather than entering the letter X in the cell where they believed the player to be standing, participants were required to enter a number from 1 to 6 based on the order of their recall. That is, participants entered the number 1 for the first player position they recalled, number 2 for the second player position and so on for each of the six players.

6.4. Test procedure

As in Study 1, participants viewed each stimulus for 5 s before recalling the position of the 6 players located outside the blue box who were playing towards the camera. In this study, however, participants received a prompt immediately following occlusion indicating the recall strategy they need to adopt, which could be separated into Whole Report or Constrained Report conditions. Constrained Report strategies included: Left (4 trials), which required participants to first recall the positions of the 3 players to left of the line then the 3 players to the right of the line; Right (4 trials), which required participants to first recall the positions of the 3 players to the right of the line and then the 3 players to the left of the line. A Whole Report strategy (5 trials) required participants to recall the positions of the 6 players in any order. The prompts were randomly ordered among the stimuli for each participant. When all the trials had been completed, participants completed the DSRS.

6.5. Data analysis

Recall accuracy was assessed identically to Study 1. Following this, participants scores were analysed based on the constraints put upon

[1] The current study used the term 'constrained report' as a slight variation on Sperling's (1960) partial report procedure.

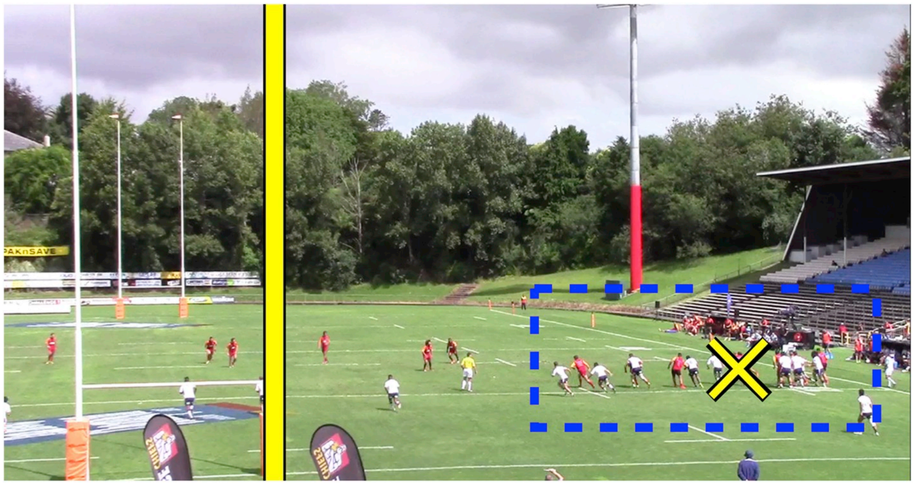

Fig. 3. Study 2 test stimuli.

their recall strategy, with each condition (Whole Report and Constrained Report) having two averages calculated. The averages calculated were the accuracy score of the first three players entered (First Three) and the average accuracy of second three players entered (Second Three); both out of a possible three. To test for differences, a 2 (Order of Recall: First Three vs Second Three) x 2 (Recall Strategy: Whole vs Constrained) repeated measures ANOVA was conducted in SPSS (Version 24, IBM, UK). Lastly, to test if participants attended to all players within the Constrained Report stimuli – i.e. not a specific half - a 2 (Order of Recall: First Three vs Second Three) x 2 (Left vs Right) repeated measures ANOVA was conducted. The main focus of the analyses was to ascertain whether Decay Theory was an acceptable explanation for slower and less accurate recall. However, a secondary consideration was to further examine the role of decision reinvestment in pattern recall by computing bivariate correlations between each factor of the DSRS and Whole and Constrained Report accuracy.

7. Results

The initial ANOVA showed a main effect for Order of Recall ($F(1,40) = 10.424$, $p = .002$, $\eta_p^2 = 0.207$), suggesting that recall was more accurate for the First Three players compared to the Second Three players. A main effect was not evident for Recall Strategy ($p > .05$) and there was also no significant interaction between Order of Recall and Recall Strategy ($p > .05$). These results are shown below in Fig. 4. The secondary ANOVA to test for differences in accuracy in the Left and Right conditions failed to reveal any significant differences or interactions (p's > 0.05). Bivariate correlations failed to reveal any significant associations between DSRS scores and accuracy in either the Whole or Constrained Report conditions.

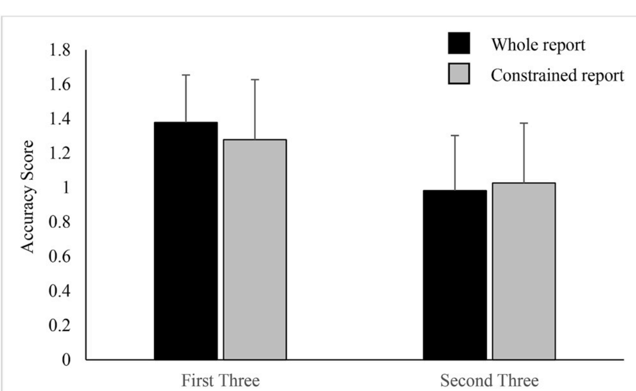

Fig. 4. Average accuracy scores for the First Three and Second Three recalled in the Whole Report and Constrained Report conditions with standard deviation bars.

8. Discussion

In Study 2, we aimed to test whether Decay Theory (Brown, 1958) was a credible explanation for why a high propensity for decision specific reinvestment was associated with both slower recall and poorer recall accuracy. It was shown that recall accuracy of the First Three players (compared to the Second Three) was significantly higher in both the Whole Report and Constrained Report conditions. Furthermore, there were no significant differences in recall accuracy based on the recall strategy adopted, showing that accuracy was the same regardless of which players were recalled first. This suggests that, as with Sperling's (1960) findings, all of the positional information was available to the participants at the point of occlusion. However, memory of these positions decayed, accounting for the reduced recall accuracy of the Second Three players. This finding also supports the results of Portrat et al (2008), which suggested that working memory is also susceptible to decay. Participants in the Portrat et al (2008) study were required to recall three to eight letters (displayed one at a time for 666 ms) in the same order that they were displayed. It was concluded that 'increasing processing time has a damaging effect on memory maintenance even when refreshing periods are similar' (p. 1564).

9. General discussion

Consistent with Kinrade et al (2015), we found that high scores on the DSRS were associated with slower recall. Kinrade et al (2015) suggested that slower recall by high reinvestors may be detrimental to performance because it represents slower processing, which leads to less information being processed before reaching the decision making threshold (the point when a decision must be made – Johnson, 2006). Similarly, Raab and Laborde (2011) assessed the influence of consciousness on speed and efficacy of tactical decision-making in handball and found that participants with a preference for intuitive (unconscious) decisions, compared to deliberate (conscious) decisions, made faster and better decisions. Research by Laborde et al. (2015) also showed that intuitive decision makers scored significantly lower on the DSRS than deliberate decision makers. Raab and Laborde (2011) suggested that performers who do not consciously monitor their decision-making optimize the use of the take-the-first heuristic (Johnson & Raab, 2003). This heuristic suggests that options are generated sequentially based on experience, similarity, strategy and environmental factors. This sequential generation means that earlier options represent better

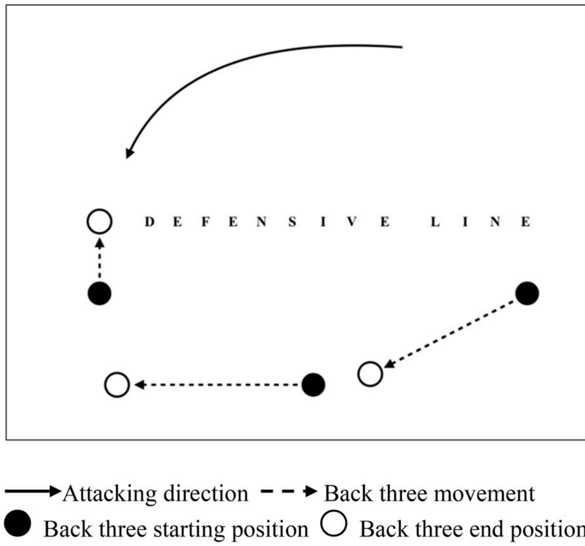

Fig. 5. Example of a back three working as a 'pendulum' (left) and a ball swinging pendulum (Newton's cradle - right).

options than later ones (Hepler & Feltz, 2012). Raab and Laborde (2011) found that the first option generated was often the most desirable (around 60% of the time) when retrospectively compared to other options generated. With respect to our findings, the more deliberate (i.e., slower) responses by high reinvestors may reflect selection of later options, which would be expected to be less accurate. Future research should consider whether performers with a high propensity for reinvestment are less likely to use a take-the-first heuristic than performers with a low propensity.

A practical application of the current findings for coaches is to promote quicker pattern dependent decision-making, particularly in high reinvestors. This will be beneficial as the information player's base their decisions on is less likely to have decayed. A simple way to convey this to player's is using a 'less is more' philosophy when generating solutions to sporting situations (Bennis & Pachur, 2006), because the first option generated is often the most desirable (Johnson & Raab, 2003). Therefore, encouraging players to trust their intuition and avoid generation of multiple options should improve both decision accuracy and speed.

Another option for coaches might be to reduce the amount of knowledge that players have to inform their decision making. Indeed, access to explicit knowledge about a task is thought to be a prerequisite for reinvestment (e.g., Klämpfl, Lobinger, & Raab, 2013; Masters, 1992; Masters, Polman, & Hammond, 1993), raising the chances that previously automatized processes are de-automatized under conditions, such as psychological pressure (Masters, 1992; see Masters & Maxwell, 2008, for a review). Masters (1992) proposed that one way to prevent accretion of explicit knowledge about a task is by utilizing an implicit motor learning approach (see Masters, Poolton, Maxwell, & Raab, 2008, for an overview), during which an intervention is used to prevent the learner from becoming aware of what he or she is learning about the task. One such intervention is analogy learning (Liao & Masters, 2001), where a concept from one situation (with which the learner is familiar), is used to convey information about the task-to-be learned without specifically providing explicit knowledge or instructions. Analogy learning may be helpful for pattern recognition in rugby. For example, Hickie and Donaldson (2015) described the dynamic defensive positioning of the back three of a rugby team (left wing, right wing, full-back) as "when one wing joins the defensive line, the full back will move across the pitch to cover the space behind them, while the opposite wing will move back to cover the space vacated by the full back" (p. 88). This explicit description of the pattern can be more succinctly conveyed using a visual analogy of the three players working as a 'pendulum' i.e. Newton's cradle (see Fig. 5).

A limitation of the current investigation is that decision reinvestment did not appear to play a role in pattern recall accuracy in Study 2. The main focus of Study 2 was to examine whether Decay Theory provided a plausible explanation for the findings in Study 1. The role of decision reinvestment was a secondary consideration, so the smaller sample size may not have been appropriate for correlational analysis. Additionally, we recruited younger (under 18) participants in Study 2, with less experience than the players in Study 1. This may have influenced the role of decision reinvestment. A further limitation is that the stimuli (or individual players) were not specifically matched for complexity, although post hoc analysis suggests that responses did not differ across the stimuli. Future work might seek to use Raab's (2003) definition of complexity to ensure stimuli are of the same difficulty.

In summary, we aimed to gain an understanding of the effects of decision reinvestment on pattern recall. We found in our first study that high reinvestors were slower to make decisions and were less accurate. Findings from our second study suggested that Decay Theory (Brown, 1958) offers a plausible explanation for poorer recall accuracy when participants were slower to respond. Further research should seek to clarify these findings, with different sports and/or stimuli (i.e., static vs dynamic images).

Conflicts of interst

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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