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**INVESTIGATING ON-FIELD DECISION  
MAKING IN RUGBY UNION**

**BY**

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A thesis submitted in partial fulfilment of the requirements for the degree of  
Doctor of Philosophy.

Te Huataki Waiora Faculty of Health, Sport and Human Performance  
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# Thesis Abstract

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Quick, accurate decision making in sport is essential for successful performance. In this five study thesis, psychological elements of decision making were investigated, guided by real world challenges encountered in a professional rugby organisation. Chapter 1 provided a background and review of relevant literature. Chapters 2 and 3 focused on pattern recall, an individual's ability to recollect specific patterns from previous experiences. The results of Chapter 2 showed that professional players with more years of rugby experience were more accurate when recalling structured patterns. However, it was shown that pattern recall tasks did not predict on-field decision making performance and thus did not warrant inclusion in talent identification programs. Chapter 2 concluded that more appropriate stimuli (structured and semi-structured patterns) should be included in future studies to investigate the viability of pattern recall tasks for talent identification purposes. Chapter 3 found that a high tendency for decision reinvestment (a predisposition to consciously process decision-making) led to slower and less accurate performance on pattern recall tasks.

In Chapter 4, the effect of reinvestment (movement specific and decision specific) and expertise on anticipation of deceptive and non-deceptive movements was investigated. The results showed experts to be significantly more accurate than novices at anticipating both deceptive and non-deceptive movements. It was also found that experts took significantly longer to respond than novices. Decision reinvestment did not play a role in anticipatory performance; however, increased movement reinvestment tendencies were associated with poorer anticipatory accuracy of deceptive movements.

Both Chapter 5 and Chapter 6 investigated the decoy runners tactic, which is a novel form of deception in the literature to date, as it centres on players who are not in possession of the ball. The tactic involves multiple players in an attacking team running option lines off the ball carrier, making it possible that any of the players could receive the ball. Runners who do not receive the ball are decoys who aim to create confusion in defences. It was shown that decoy runners were significantly

more effective when they displayed certain characteristics to attract defenders' attention (i.e., hands up as if receiving the ball and line change as if exploiting a gap in the defensive line). Chapter 6 followed up on a claim made in the discussion of Chapter 5, that the increased effectiveness of decoy runners (when displaying certain characteristics) was caused by momentary inattention blindness of the player who received the ball. This study showed that the player who received the ball was more likely to be unnoticed when attention was diverted by a secondary task – fitting the description of inattention blindness (an individual failing to register an unexpected object clearly within their field of vision when their attention is diverted to another object or task (Mack & Rock, 1998)). The findings are summarised and discussed in the context of relevant research in the decision making field. Practical applications for coaches are provided and future directions for research are considered.

# Acknowledgements

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This three year journey has been the most challenging of my life thus far. One thing is for certain, without the support I have been given, completing this PhD would not have been possible. I would therefore like to take the opportunity to express my gratitude to those who have helped along the way.

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# Declaration

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I declare that this thesis represents my own work, except where due acknowledgement is made, and that it has not been previously included in a thesis, dissertation or report submitted to this University or to any other institutions for a degree, diploma or other qualification.

A handwritten signature in black ink, consisting of a stylized 'S' followed by a long horizontal stroke.

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Sebastian Sherwood



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# Publications arising from the work generated in this thesis

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## Journal articles

Sherwood, S., Smith, T., & Masters, R. S. W. (2018). Pattern recall, decision making and talent identification in rugby union. *European Journal of Sport Science*, 1-8.

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Sherwood, S. M., Smith, T. B., & Masters, R. S. W. (under review). Anticipating deceptive movements in rugby union: The role of reinvestment. *The Journal of Sport and Exercise Science New Zealand*

Sherwood, S., Masters, R. S. W., & Smith, T. B. (2018). Examining deceptive behaviours by attackers in rugby union: The influence of decoy runners on defensive performance. *International Journal of Sports Science & Coaching*, 13(6), 1100-1107.

Sherwood, S. M., Smith, T. B., & Masters, R. S. W. (under review). Inattention blindness in rugby union: A clean break. *Psychology of Sport and Exercise*

## Conference presentations

Sherwood, S., Smith, T., & Masters, R. S. W. (2018). Pattern recall, decision making and talent identification in rugby union. *Sport and Exercise Science New Zealand Annual Conference 2016. Cambridge, New Zealand*

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# Chapter 1

## Introduction

*“Decision making is the hardest part of rugby”*  
(Former South Africa Coach, Brendan Venter, 2015)

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### **Decision making in sport overview**

In fast paced sports, the ability to make quick and accurate decisions can often determine the outcome of a contest. It is therefore unsurprising that it is an area of so much interest for academics, coaches and players alike. Decision making is notoriously difficult to measure and, more importantly, improve. Kaya (2014) defined decision making as “the intellectual process resulting in the selection of a belief or a course of action among several different options. Every decision making process produces a final choice that may or may not prompt action” (p. 333).

Rugby players are required to make countless decisions within an 80-minute match, which vary based on the time-constraints and complexity of the situation. The opportunities for action, also known as affordances (Gibson, 1966), occur almost constantly with or without the ball in hand, in both attack and defence. These decisions have often been described using a continuum, with intuitive decision making at one end and deliberate decision making at the other (Raab & Laborde, 2011). Intuitive decisions are characterised by quick reactions, when a player is under extreme time constraints and has little time to use conscious thought to make their decision. For example, when anticipating a side-step a player needs to make a decision quickly in order to perform an effective tackle on the opposition player. At the other end of the continuum, deliberate decisions are typified by having more time to make a decision, during which players can consciously weigh up their options and decide which decision is optimal. For example, a captain usually has

ample time when deciding whether to kick for touch, kick at goal, take a scrum or a quick tap when awarded a penalty in rugby. Betsch and Kunz (2008) raised the concept of ‘decisional fit’ or ‘decisional misfit’ – based on whether the decision making style adopted (i.e., intuitive vs deliberate) matched the features of the situation (i.e., complexity of decision, temporal constraints etc). An example of decisional misfit would be using a deliberate strategy when deciding whether to pass or run under extreme time constraints in rugby – too much deliberation would be likely to result in the individual being tackled before executing the movement.

### **Theories of decision making in sport**

To understand decision making processes, nearly 300 explanations and models have been devised (Bar-Eli, Plessner, & Raab, 2011). The following section will summarise four models that focus on time-constrained decision making, which is most relevant for rugby players.

#### *Subjective expected utility theory*

The subjective expected utility (SEU) theory was devised by Edwards (1954). The theory is based on two variables, the probability of success (uncertainty) and the value of the chosen object (utility). Edwards (1954) proposed that the option decided upon is the option that has the highest value when uncertainty and utility are multiplied. For example, a rugby player may have two options; throw a high risk pass that would almost certainly lead to a try or run the ball into contact to ensure that the ball is retained. Throwing the high risk pass would have a lower probability of success but a high utility (try), however holding on to the ball would have a high probability of success (retaining possession) but lower utility (ball retained to attempt to score in following phases of play). A clear limitation of this theory is the based on the idea of bounded rationality (Simon, 1991). Bounded rationality relates to the cognitive limitations of humans, in this case, when making decisions with insufficient time to fully process the information at hand. This makes it almost impossible to accurately choose the option with the highest subjective utility.

### *Decisional field theory*

The Decision Field Theory (DFT; Busemeyer & Townsend, 1993; Roe, Busemeyer, & Townsend, 2001) furthers the SEU model by including a temporal dimension. The model assumes that the preference for options changes over time based on the dynamic situation. The DFT outlines different processes involved in making a decision; first, an initial preference towards a certain option is assumed (for example, passing to a powerful teammate who consistently breaks the defensive line). Second, sampling of the information is sequentially processed based on the importance to the decision maker (for example, if speed is valued above power then the first options generated would likely involve the decision makers quicker teammates). Third, affective responses are paired to options generated, influencing their likelihood of being selected. For example, if a player has dropped the ball on the last two occasions that he or she received a pass then the decision maker will have a negative reaction to passing to this teammate. DFT suggests that, through consideration of these three assumptions, a threshold is met whereby an option is considered ‘good enough’ to determine choice.

### *Ecological dynamics theory*

Ecological Dynamics Theory (Araujo, Davids, & Hristovski, 2006) has been influenced by elements of ecological psychology, neurobiology and natural sciences. This theory rejects typical information processing approaches, which assume that decisions are made when information received from the environment and processed before an output (movement) is produced (Welford, 1968; Whiting, 1969). Ecological dynamics works on the premise of direct perception, whereby learning couples the perceived information directly to actions. A key component of the theory is that decision making is not an isolated event, but rather is a constant (dynamic) flow of perception and action (Cordovil, Araujo, Davids, Gouveia, Barreiros, Fernandes, & Serpas, 2009; Headrick, Davids, Renshaw, Araujo, Passos, & Fernandes, 2011; Orth, Davids, Araujo, Passos, & Renshaw, 2014). For example, when deciding between passing and kicking, performers constantly consider the changing task constraints, such as the position of teammates/defenders, kinematics of teammates/defenders, field location, etc.

### *Simple heuristic approach*

The Simple Heuristics approach, first described by Gigerenzer and Todd (1999) and applied to sport by Johnson and Raab (2003) has significant support in the decision making domain. This approach encapsulates the idea of bounded rationality (Simon, 1991) by having a number of different heuristics based on the demands of the environment (e.g., extreme time constraints) or individual differences. Heuristics can be described as ‘rules of thumb’ that are the building blocks of decision making (Raab, 2012). These heuristics can describe how performers (or coaches, referees, etc) search for information, stop searching for information and decide quickly and accurately (Raab, 2012). For example, the ‘take-the-first’ heuristic (Raab & Johnson, 2007) explains how options are generated in order of validity and the first option generated is decided upon. Importantly, research has shown that (1) experts generate more successful options than non-experts and (2) the first option generated is more successful than later generated options (Raab & Laborde, 2011). Other heuristics in sport performance include the ‘recognition’ (Pachur & Biele, 2007) and ‘take-the-best’ (Todorov, 2001) heuristics.

### **Researching decision making in sport**

The most common methodology used to study decision making is video based tasks, where participants are required to respond to video scenarios (Lorains, Ball, & MacMahon, 2013a; Lorains, Ball, & MacMahon, 2013b; Put, Wagemans, Pizzera, Williams, Spitz, Savelsbergh, & Helsen, 2016). Other methods of investigating decision making include interviewing players about previous decision making instances (Lenzen, Theunissen, & Cloes, 2009), using liquid crystal glasses that block vision at certain points during the performance in situ (Müller & Abernethy, 2006; Starkes, Edwards, Dissanayake, & Dunn, 1995) and recording gaze behaviour during the performance (Dicks, Button, & Davids, 2010; Panchuk & Vickers, 2006; Williams, Vickers & Rodrigues, 2002; Williams & Davids, 1998).

Studies that rely on video based tasks will often measure the speed and accuracy of decision making centered on an independent variable. These variables include learning and instructional techniques (Raab, 2003), the speed of video playback (Lorains et al, 2013a; Lorains et al, 2013b), viewing perspective (Mann, Farrow, Shuttleworth, Hopwood, & MacMahon, 2009), spatial occlusion (Huys, Smeeton, Hodges, Beek, & Williams, 2008) or temporal occlusion conditions (Jackson, Warren, & Abernethy, 2006). The speed and accuracy of decisions, as tested using the video scenarios, has been shown to be the best predictor of skilled performance on the field of play (Mann, Williams, Ward, & Janelle, 2007). Few studies (with the exception of Belling & Ward, 2015; Ward, Suss, & Basevitch, 2009; Fadde, 2009; Williams, Ward, & Chapman, 2003) have investigated whether the improvements seen in the video tasks transfer to the field. The limited research seems to suggest that improvements do transfer, but more research will help to ascertain the true benefit of off-field training through video tasks.

A long-standing limitation of video tasks is that 2D video stimuli may not adequately capture the dynamic nature of sport (Abernethy, Burgess-Limerick, & Parks, 1994). Recent advancements in technology, such as virtual reality and 3D videos, provide more realistic methods to measure decision making. Virtual reality consists of creating immersive environments, typically viewed through a headset, giving an interactive point of view, based on the user's head tracking (Sherman & Craig, 2019). Similarly, 3D videos are commonly viewed through virtual reality headsets to give individuals a dynamic point of view perspective. Reilly, Johansson, Huang, and Churches (2016) believe that these methodologies are appropriate to train and test an athlete's decision making, stating that repetitively experiencing scenarios without the risk of injury will help players to develop their perceptual expertise.

### **Expert-novice differences in decision making**

Typical approaches to researching decision-making have involved identifying the differences between experts and non-experts (Rowe, 1998; Travassos, Araújo, Davids, O'Hara, Leitão, & Cortinhas, 2013; Lorains, Ball, & MacMahon, 2013). Key research has shown that experts typically have less fixations of a longer

duration than novices (Mann et al., 2007). Mann and colleagues (2007) stated that saccadic eye movements reduce the amount of information extracted from the environment. As such, for non-experts increased fixations cause key cues to be missed and incorrect decisions to occur. Further research has shown that experts use information from distributed sources to make decisions (Ward et al., 2009; Loffing & Hagemann, 2014). For example, expert badminton players' judgements of shot depth improved when point light displays of additional body parts were progressively included within the display (i.e., racket arm, plus head and non-racket arm, plus lower body). Novices' judgements, however, did not improve when additional body parts were included. In addition to having a more efficient search strategy, experts have also been shown to direct their attention to the information rich areas of the environment. Savelsbergh, Williams, van der Kamp, & Ward (2002), for instance, tracked the eye movements of expert and novice goalkeepers while saving penalty kicks. Their findings suggested that experts directed their attention predominantly to the kicking leg, non-kicking leg and ball areas whereas novices directed their attention to the trunk arms and hips. The areas focused on by the experts were shown to be more informative for predicting shot direction.

### **The effect of consciousness on decision making**

Conscious processing of decision making (and movement skills) leads to the de-automatization of previously automatized processes, which leads to performance decrements (Deikman, 1969). As mentioned previously, decisions in sport can be viewed on a continuum from intuitive to deliberate. A common consensus between academics is that consciously controlling the decision making process for intuitive decisions (which typically occur with little or no conscious engagement) is detrimental to performance (Kinrade, Jackson, & Ashford, 2015; Kinrade, Jackson, Ashford, & Bishop, 2010). Research therefore promotes implicit (non-conscious) processes as opposed to explicit (highly conscious) processes. Implicit processes occur with minimal awareness and result in knowledge that cannot generally be verbalized (Masters, 1992). Explicit processes occur with awareness and tend to result in declarative, verbalizable knowledge, such as facts or rules (Masters, 1992). Measuring the number of explicit rules reported by an individual can be used to measure consciousness of decision making processes. Smeeton, Williams, Hodges,



and Ward (2005) found a strong correlation between the number of explicit rules reported and slower decision making of tennis strokes under pressure. A number of theories have the consistent theme that consciously controlling movement or decision making processes leads to performance decrements or ‘paralysis by analysis’. These theories include the Theory of Reinvestment (Masters, 1992) and Explicit Monitoring Theory (Beilock, Carr, MacMahon, & Starkes, 2002).

### *The Theory of Reinvestment*

Reinvestment is a concept originally theorized by Masters (1992) and Masters, Polman, and Hammond (1993), which explains the process of an individual controlling their movements by manipulating conscious, rule-based knowledge, via working memory. Much research has highlighted reinvestment as a cause of skill breakdown under pressure (see Masters & Maxwell, 2008, for a review).

There are key assumptions that underpin the theory; first, performers must have access to explicit knowledge for reinvestment to occur. For example, Smeeton et al., (2005) found that performers who received implicit training reported less explicit rules, and performed better, than those who received explicit training. Poolton, Masters, and Maxwell (2006) also provided evidence for a correlation between explicit knowledge and the propensity for reinvestment. Therefore, avoiding the accumulation of explicit rules lessens the ability to reinvest. Second, motor and decision making skills can be processed in a step-by-step manner (Beilock et al., 2002). It is thought that disruptions of performance occur because automatized processes are broken down into separate units, as in the early stages of learning (Masters, 1992). “Once broken down, each unit must be activated and run separately, which slows performance and, at each transition between units, creates an opportunity for error that was not present in the integrated control structure” (Beilock & Carr, 2001, p. 715). It has also been suggested that reinvestment is a process that is associated with working memory (WM). WM is “capable of retaining a small amount of information in an active state for use in ongoing tasks” (Furley & Memmert, 2015, p.1). Skill breakdown can either be caused by “blocking up” WM’s limited capacity with ruminations or worries about previous performances or by “loading WM” with declarative knowledge, which inhibits

smooth execution (Laborde, Furley, & Schempp, 2015; Beilock & Carr, 2005; Beilock & DeCaro, 2007; Masters & Maxwell, 2008; Masters et al., 1993).

‘Dartitis’, similar to the yips in golf, is an example of reinvestment causing motor skill breakdown under pressure. It is defined by the Collins English dictionary as “nervous twitching or tension that destroys concentration and spoils performance”. In 2017, Berry van Peer suffered from dartitis, typified by difficulty releasing the dart, which was compounded by the crowd vocalising their frustration with the length of time he was taking. Fellow darts player Wayne Mardle (Sky Sports, 2017) defended van Peer by saying “No player wants it, but the thing is with Berry, he is looking for his old routine, but he can't do it. He just cannot find it and the more he is thinking about it, the harder it becomes”.

#### *Movement Specific Reinvestment*

When the Theory of Reinvestment was originally conceptualised, it was based primarily on disruptions of motor skills. Research into the area would initially use the Reinvestment Scale (Masters et al., 1993) to measure an individual’s propensity to consciously monitor their movements. Following advancements in the definition of reinvestment, and to address the fact that the original scale did not specifically refer to movement, the Movement Specific Reinvestment Scale (MSRS) was developed (Masters, Eves, & Maxwell, 2005). The MSRS measures an individual’s propensity for movement self-consciousness (style and perceived public perception) and for conscious motor processing (explicit control of movement during performance). Research has shown that the propensity for reinvestment is positively correlated to a range of skill disruptions, such as falls by elderly people (Wong, Masters, Maxwell, & Abernethy, 2008), surgery performance (Malhotra, Poolton, Wilson, Ngo, & Masters, 2012), a football ‘wall volley’ task (Chell, Graydon, Crowley, & Child, 2003) and field-hockey dribbling (Jackson, Ashford, & Norsworthy, 2006).

### *Decision Specific Reinvestment*

In order to understand whether reinvestment causes task disruption under pressure in perceptual skills, as in motor skills, Kinrade et al (2010) developed the Decision Specific Reinvestment Scale (DSRS). As with the MSRS, the DSRS measures two factors: 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 suggests that individuals who score highly on the DSRS perform worse, and make slower decisions, under pressure in sports such as basketball (Kinrade et al., 2015), netball (Jackson, Kinrade, Hicks, & Wills, 2013), handball (Laborde, Dosseville, & Kinrade, 2014) and korfbal (Kinrade, et al., 2010). Kinrade et al (2010) concluded that deliberate decision making under time constrained, complex and changing environments impairs performance.

Kinrade et al's (2015) study investigated the validity of the DSRS to predict performance in a complexity controlled, basketball decision making task. Skilled basketball players were required to respond to a video of a common basketball scenario with either two-choices (low complexity) or four-choices (high complexity). Players had to indicate the player in the best position to pass to, as quickly and accurately as possible. Their main finding was that high DSRS scores were associated with reduced accuracy under pressure in the high complexity condition. Furthermore, rumination was a significant predictor of slower response time in the low complexity conditions and poorer accuracy in high complexity conditions. Dispositional reinvestment has also been shown to influence decision making of officials in netball (Burnett, Bishop, Ashford, Williams, & Kinrade, 2017) and football (Poolton, Siu, & Masters, 2011). For example, Poolton et al (2011) found that rumination was associated with inhibited decision making. The authors also found a bias towards home teams, with high ruminating umpires giving significantly more decisions against the away team.

## **Pattern Recognition**

Pattern recognition has been identified as one of the most significant predictors of anticipation skill in sport (Williams & Davids, 1995; Smeeton, Ward, & Williams, 2004). In sport, pattern recognition involves players making judgements of whether patterns are novel or identical to those previously experienced (Smeeton et al., 2004). Research in the area has consistently shown that experts are able to recognise and/or recall structured patterns more accurately than non-experts. Importantly, when recalling unstructured patterns, experts' recall accuracy is reduced to that of a novice (Chase & Simon, 1973; Borgeaud & Abernethy, 1987; Starkes & Deakin, 1984; Williams, Davids, Burwitz, & Williams, 1993). Chase and Simon's (1973) 5 second recall task in chess (see also de Groot, 1965), for example, aimed to determine whether there were differences in pattern recognition ability between varying skill levels in chess, from novices to chess masters. In their study, participants recalled structured or random positions of the chess pieces from a chessboard that they had previously seen for just 5 seconds. Chess masters were significantly better than novices and intermediate level players at recalling structured positions; however, there were no significant differences in recall of random positions. Chase and Simon (1973) concluded that the expert's improvement was not due to enhanced memory capacity, but rather that they encoded and retrieved information from chessboards differently to non-experts.

### *Measuring pattern recognition*

Research into pattern recognition has taken two distinct methodologies. First, as in Chase and Simon's (1973) study, pattern recall tasks are implemented. These tasks require participants to recall the positioning of teammates and/or opponents, who have typically been seen for a short duration. Pattern recall tasks have been used in sports, such as chess (de Groot, 1965; Chase & Simon, 1973), basketball (Allard, Graham, & Paarsalu, 1980; Gorman, Abernethy, & Farrow, 2011), soccer (Williams et al., 1993) and rugby union (Farrow, McCrae, Gross, & Abernethy, 2010). Second, researchers have taken a recognition approach (Smeeton et al, 2004; Didierjean & Marmeche, 2005; Gorman et al, 2011). Recognition methodologies involve participants viewing video clips of patterns from a particular sport. A

selection of video clips is then shown, including clips that have not previously been seen. The participant must indicate whether the clip has previously been viewed or whether the clip was not in the original array.

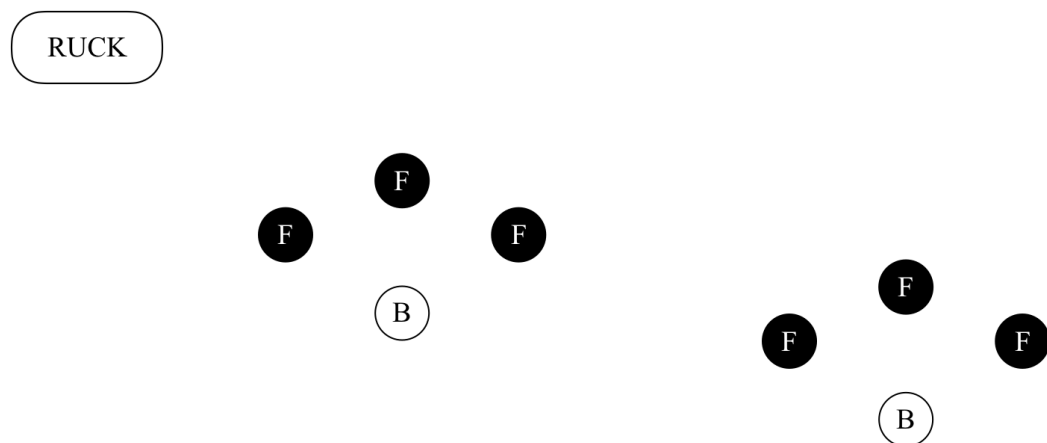
### *Ecological validity of pattern recognition research*

To date, only one study has investigated how pattern recognition ability is correlated to on-field decision making performance (van Maarseveen, Oudejans, Mann, & Savelsbergh, 2016). In van Maarseveen et al's (2016) study, on-field performance of talented soccer players was related to measures of anticipation, decision making and pattern recall. Their results revealed that on-field performance was not predicted by any of the perceptual tests. However, as this is the only study of its kind to date, further research needs to be completed to understand the true validity of such tests. Furthermore, Williams and Ericsson (2005) questioned the validity of pattern recall tasks, as recalling the positions of teammates or opponents is seldom required in sport. Gorman, Abernethy, and Farrow (2013), however, directly answered this concern by suggesting that the ability to recall these positions assists players in predicting what is likely to happen next and thus helps athletes to choose the most appropriate response. In an attempt to increase the validity of these tasks researchers have moved away from static images to dynamic videos - with player positions at the point of occlusion, or slightly after, needing to be recalled (for example Gorman et al., 2011). Interestingly, Gorman, Abernethy, and Farrow (2012) investigated the difference between recall of static and dynamic stimuli. Their findings showed no significant difference in experts' recall accuracy in static compared to dynamic stimuli.

### *Expert advantage in pattern recognition*

Experts have frequently demonstrated superior pattern recognition ability on structured patterns and similar ability on unstructured patterns compared to non-experts. Different mechanisms have been used to explain these differences, yet there have been consistent themes throughout the research conducted in the past 40 years. van Maarseveen, Oudejans, and Savelsbergh (2015) found that more experienced players, who scored more highly on the pattern recall task,

implemented a different search strategy compared to those who scored less highly. This search strategy involved a higher search rate with shorter fixation durations. Another explanation for experts displaying greater structured pattern recognition skill is the Theory of Chunking (Chase & Simon, 1973; Borgeaud & Abernethy, 1987; Allard et al, 1980; Gorman et al, 2012). This theory suggests that an expert's superiority is not due to enhanced memory capacity but rather due to an encoding mechanism. The experts are thought to group information in a significant way as a single entity or 'chunk' based on previous experience. This mechanism avoids the usual restrictions of short-term memory (Chase & Simon, 1973). As structured stimuli are viewed frequently by experts they will be able to group this information in a more significant way than novices. For example, Figure 1 displays a pattern that experts experience many times within a rugby game, in which two groups of three forwards with a back following behind, create diamond formations. Novices will not have seen such patterns beforehand and are therefore less able to differentiate and chunk these players in a memorable way. As unstructured stimuli are devoid of patterns and have larger variability it is difficult for experts and novices alike to chunk the information into memorable chunks for future use.



**Figure 1.** Example of diamond pod formations in rugby

Research has also suggested that pattern recognition ability may transfer across sports that contain similar structures of play. Abernethy, Baker, and Côté (2005) asked skilled and novice netball, basketball and field hockey players to complete a pattern recall task consisting of structured patterns from their own sport (domain

specific) and the other two sports (non-domain specific). Consistent with previous findings, skilled players - compared to less skilled players from the same sport - recalled domain specific patterns more accurately. Interestingly, experts' non-domain specific pattern recall accuracy was also higher than novices' domain specific accuracy. Smeeton et al (2004) also showed transferability of pattern recognition ability between invasion games (field hockey to football), but not to more different sports (i.e., volleyball to field hockey or football). These findings suggest that some elements of a pattern are general in nature and can transfer between sports.

### **Attention allocation**

Perceptual skills are imperative for performance in many everyday tasks, such as reaching and grasping (Goodale & Westwood, 2004), driving (Horswill & McKenna, 2004) and in medical professions (Snowden, Davies, & Roling, 2000). The ability to focus on relevant cues and ignore irrelevant cues is fundamental to both everyday life and sporting performance; knowing where and when to look is crucial. In sport, athletes need to be able to identify the most information-rich areas of the display, direct their attention appropriately, and extract meaning from these areas efficiently and effectively (Williams, Davids, & Williams, 1999). McPherson (2000) discovered that experts hold extensive procedural and declarative knowledge that allows them to extract the most relevant information from the environment to predict future events. An interesting phenomenon within this area of sport psychology, that has a growing research base, is the inattentional blindness paradigm.

### *Inattentional blindness*

Inattentional blindness explains instances where observers fail to register an unexpected object clearly within their field of vision if their attention is diverted to another object or task (Mack & Rock, 1998). The infamous gorilla experiment conducted by Simons and Chabris (1999) demonstrated this phenomenon. In their study, participants watched a video of two groups of people wearing different coloured bibs. Each group of players was passing a basketball among themselves

while moving around on the court. Participants were instructed to count the number of passes made by one of the groups while an individual wearing a gorilla costume (unexpected object) walked amongst the players (see Figure 2). Remarkably, 50% of the participants did not report seeing the gorilla. Simons and Chabris (1999) proposed that participants were inattentionally blind to the unexpected object (i.e., the gorilla) as their attention was diverted to another object/task (counting passes). Further studies have investigated inattentional blindness in real-life events, such as, radiologists interpreting scans (Potchen, 2006; Drew, Võ & Wolfe, 2013), driving (Pammer & Blink, 2013) and witness reports to crimes (Chabris, Weinberger, Fontaine, & Simons, 2011).



**Figure 2.** A screen shot of the video used by Simons and Chabris (1999)

Inattentional blindness is also thought to be prevalent in sport. Memmert and Furley (2007), for example, suggested that inattentional blindness may explain why team sport players sometimes retrospectively report that they did not see a teammate in a promising scoring position. In a handball study, participants were required to choose the optimal team mate to pass to, while concurrently performing an attention diverting task based on a defender's positioning. The task was constructed so that a teammate was unmarked in a scoring position and as such was the optimal player to pass to. The results showed that 55% of participants failed to notice, and thus pass to, this optimal player when they were required to complete the attention



diverting task. However, when players were allowed to solely focus on their teammates, all participants selected the optimal player. The authors concluded that the presence of the unmarked teammate was not registered because attention was directed towards a defender, which caused inattention blindness. Further research in handball (Memmert, 2011) and basketball (Furley, Memmert, & Heller, 2010), has helped to solidify the claim that inattention blindness is a common occurrence in sport.

As of yet, all of the previous research into inattention blindness in sport has tried to prevent the phenomenon to ensure that players do not miss an attacking opportunity. However, inattention blindness can also be used to deceive opposition players into making incorrect or slowed decisions. A simple example of this is in volleyball where the ball is set for a spike. Volleyball teams will often have one player jumping for a ‘dummy spike’, attracting attention from the opposing team, only for the ball to be set to a secondary jumper (within the opposition’s field of vision). From a coach’s perspective, it is therefore imperative to understand what techniques can be used to cause and maximize inattention blindness to create confusion in opponents.

#### *Inattention blindness vs misdirection*

A criticism of the original inattention blindness papers in sport is that misdirection may be a more plausible explanation than inattention blindness. As mentioned above, inattention blindness occurs when an individual fails to register an object – importantly, within their field of vision - when attention is otherwise occupied. Misdirection, however, is the “strategy of combining cues to divert the spectator’s attention away from a secret action” (Moran & Brady, 2010). Misdirection is commonly used in magic tricks; for example, a magician will divert an observer’s attention to their left hand, while implementing sleight of hand with their right hand out of the observer’s view. Simons and Chabris’s (1999) famous gorilla experiment, however, demonstrates inattention blindness because the gorilla was clearly in the participant’s field of vision and the basketball actually crosses the gorilla’s path (no sleight of hand occurs). In order to truly test for inattention blindness, both the unexpected object and the attention demanding secondary task

must both occur in the same vicinity. Interestingly, however, gaze behaviour cannot completely distinguish misdirection from inattentional blindness. Kuhn and Findlay (2010), for example, found that only 30% of participants who noticed an unexpected event in a magic trick were fixating in the vicinity of the event. The other 70% of participants detected the event ‘covertly’, presumably via peripheral vision. Covert attention relates to attending to stimuli without the movement of the eyes, whereas overt attention requires saccades and eye fixations to shift attention (Wu & Remington, 2003).

#### *Factors facilitating inattentional blindness*

Research into inattentional blindness has attempted to understand what factors maximize the chances of the phenomenon being experienced. Results have shown that certain characteristics of the unexpected object affect the chances of it being unregistered. These characteristics include: colour (Green, 2004; Koivisto, Hyönä, & Revonsuo, 2004), luminance (Most, Scholl, Clifford, & Simons, 2005), shape (Most et al, 2005), size (Mack & Rock, 1998), exposure time (Kreitz, Furley, & Memmert, 2016), animacy (Calvillo & Jackson, 2014), distance from the attentional focus (Newby & Rock, 1998), contextual relevance (Pammer & Blink, 2013) and similarity to attended items (Most et al., 2001).

Pammer and Blink (2013), for example, investigated the effect of semantic congruency on inattentional blindness. Semantic congruency refers to the agreement or correspondence between the meanings of several components. Pammer and Blink’s (2013) method required participants to view images of a driving situation and report whether the situation was safe or unsafe. Some stimuli also included an unexpected stimulus that was either semantically congruent (SC) or semantically incongruent (SI) to the environment. In a city scene, the unexpected stimuli were either a business man (SC) or a kangaroo (SI), whereas in a country scene the same stimuli were displayed with the opposite definitions. The results showed that in city scenes participants were more likely to notice the business man (33% detection rate) than the kangaroo (12% detection rate). Pammer and Blink (2013) concluded that when monitoring a visual stimulus, a viewer is more likely to notice an unexpected object if it shares some features with the stimulus being

monitored. An example of how this may be implemented in rugby is by swapping players' traditional positions and/or roles to create inattentional blindness in opposition players. The image below (Figure 3) takes Pammer and Blink's (2013) findings to the extreme; however Hyman Jr, Boss, Wise, McKenzie, and Caggiano (2010) did show that individuals were less likely to notice a unicycling clown when their attention was maintained by using a mobile phone.



**Figure 3.** Humorous depiction demonstrating how semantic incongruity facilitates inattentional blindness

Another important factor contributing to inattentional blindness is the attention demands of the attentionally diverting task. An unexpected object is more likely to be noticed if the attentionally diverting tasks do not require much attention, i.e., there are more attentional resources available to devote to the rest of the environment (Most et al., 2005; Simons & Chabris, 1999).

### **Decision making of deceptive movements**

The use of deception to inhibit the effectiveness of an opponent's decision making is common in sport; however, the underlying processes are still unclear. Jackson et al (2006) defined the aim of deception as "providing information that misleads or 'fools' an observer into making an incorrect judgment" (p. 356). Deception research to date has investigated football penalty kicks (Smeeton & Williams, 2012),

handball shots (Cañal-Bruland & Schmidt, 2009), volleyball attacking hits (Güldenpenning, Steinke, Koester, & Schack, 2013), rugby side-steps (Jackson et al., 2006; Brault, Bideau, Kulpa, & Craig, 2012; Mori & Shimada, 2013), football ‘stepovers’ (Wright, Bishop, Jackson, & Abernethy, 2013; Jackson, Barton, Ashford, & Abernethy, 2018) and basketball passes (Sebanz & Shiffrar, 2009).

The first investigation of the ability to detect deceptive motor tasks was conducted by Runeson and Frykholm (1983). In this study, participants watched point light displays of actors lifting boxes onto a table; in some cases, actors attempted to mislead observers by pretending the box was heavier than it was. The results showed that (1) participants could accurately estimate the weight of the box when actors performed genuine actions and (2) participants were successful in detecting deceptive actions. Richardson and Johnston (2005) argued that an observer can detect these deceptive actions as the actors can only approximate the kinematics of the genuine action - they cannot completely replicate the true movement pattern. They described this as the ‘non-substitutability’ of actions. A similar study in sport found that only experts could distinguish deceptive basketball passes from true basketball passes when viewing point light kinematics (Sebanz & Shiffrar, 2009). Further findings have shown skilled performers to have better ability to identify deceptive from non-deceptive movements (Cañal-Bruland & Schmidt, 2009; Abernethy, Jackson, & Wang, 2010; Cañal-Bruland, van der Kamp, & van Kesteren, 2010).

### *Measuring decision making of deceptive movements*

Temporal occlusion and spatial occlusion are two methodologies typically adopted (and sometimes used in conjunction) in deceptive research. The temporal occlusion paradigm uses dynamic videos that are terminated at various timepoints, with participants predicting the outcome of the action (Mori & Shimada, 2013). This methodology is used to specify the temporal course of cue extraction. In the spatial occlusion paradigm, observers view actions with specific body parts masked (Mori & Shimada, 2013). For example, during a side-step lower body kinematics can be excluded so that decisions about the movement outcome can only be based on the actions of the upper body. Progressively including or excluding body parts allows

researchers to understand the key areas from which individuals extract information to make accurate decisions.

An important consideration when investigating decision making for deceptive actions is the stimulus type. For instance, Sebanz and Shiffrar's (2009) study used videos (normal and point light) and static images of basketball passes or fake passes. Expert and novice basketball players were required to identify whether the stimuli displayed a true or fake pass. Expert responses were significantly better than novices when responding to normal and point light videos, but not static images.

#### *Expert advantage in responding to deceptive movements*

Expert performers are said to be better at responding to deceptive movements due to experience in both perceiving and performing the observed actions (Cañal-Bruland et al., 2010). The importance of performance expertise can be explained by Rizzolatti's (2005) concept of mirror neurons, which are said to fire during both motor preparation and imagery of the same motor actions. Mirror neurons transform information from the visual field into knowledge of the performer's movement actions by comparing it to their own technique (Rizzolatti, Fogassi, & Gallese, 2001). For example, Aglioti, Cesari, Romani, and Urgesi (2008) discovered that only elite basketball players could anticipate the outcome of a free shot based on body kinematics alone. Coaches, journalists and novices could only predict the outcome based on ball trajectory. Similarly, Tidoni, Borgomaneri, di Pellegrino, and Avenanti (2013) provided evidence that action simulation is also implemented when detecting deceptive movements. This study showed that watching an actor lifting and placing objects facilitated the observers' motor system with greater muscle innervations for suspected heavier weights. It has been shown that the motor repertoire individuals possess moderates the motor resonance of such actions (Calvo-Merino, Glaser, Grèzes, Passingham, & Haggard, 2004).

Jackson et al (2006) and Abernethy, Zawi, and Jackson (2008) argued that experts' superior decision making for deceptive actions is due to greater perceptual experiences. These authors suggested that experts have an enhanced ability to 'read' the kinematics of the movement and pick up advanced information that specifies

the outcome. Additional differentiating factors have been shown by Brault et al (2012) in a study of side-steps in rugby. Brault et al (2012) found that experts waited significantly longer to respond than novices and showed significantly fewer movements in the wrong direction. Furthermore, any movements in the incorrect direction were of lower amplitude than those of novices. They concluded that this was due to the experts' ability to tune in to honest kinematics that indicate final running direction (in this case centre of mass), which minimises movement in the wrong direction.

### **Thesis outline**

The current thesis investigates different elements of decision making, guided by real world challenges encountered in a professional rugby organisation. The aim of the thesis was to provide insight into some of these challenges using robust scientific methodologies, both aiding the organisation and contributing to knowledge within the wider scientific community.

The first challenge was highlighted by the talent identification manager of a professional rugby franchise in New Zealand, who was struggling to objectively measure young players' decision making ability. Pattern recall tasks have previously been used to measure decision making (e.g., Gorman et al., 2011), yet it is unclear how performance of these tasks is correlated to on-field performance. van Maarseveen et al (2016) completed the only study investigating the validity of pattern recall tasks to date, reporting that in-situ performance of talented female soccer players was not predicted by performance on pattern recall tasks. Study 1, reported in Chapter 2, aimed to further examine the validity of pattern recall tasks using a rugby union specific task. Professional rugby players' performance on the task was compared to a number of measurements of on-field decision making ability. For pattern recall tasks to be seen as a valid tool, accuracy scores on the task should be positively correlated with on-field decision making ability.

As mentioned previously, the Theory of Reinvestment has gained considerable attention in the decision making domain in the last decade. Thus far, research has shown that consciously monitoring decision making processes detrimentally affects

performance (e.g., Kinrade et al., 2015; Kinrade et al., 2010). In Study 2 (Chapter 3), the individual propensity to reinvest about decisions (measured using the DSRS) was investigated in conjunction with pattern recall speeds and accuracy. A similar methodology to Study 1 was adopted, with professional rugby players completing a rugby specific pattern recall task. Participants were required to recall the positions of players viewed for just 5 seconds as quickly and accurately as possible. Scores on the DSRS were then examined with respect to response accuracy and response speed. It was hypothesised that a high propensity to consciously process decision making processes (i.e., high scores on the DSRS) would correlate with slower and/or poorer recall accuracy.

Following the theme of reinvestment, the defence coach was interested in understanding how consciousness affects decision making under extreme time constraints (in this case tackling an evasive attacker). Anticipating an attacker's intent is crucial for tackle efficacy, as shown by Wheeler, Askew, and Sayers (2010), who identified that 72% of tackle breaks were a result of an attacker side-stepping the defensive player. Study 3 (Chapter 4) therefore investigated the effect of consciousness on such decisions; elite, intermediate and novice rugby players were required to anticipate the final running direction of an opponent changing direction (with or without deception). DSRS and MSRS scores were collected from each player and analysed in the context of anticipation accuracy and speed. Research in the reinvestment domain thus far has overlooked anticipation of deceptive and non-deceptive movements. As with Study 2, it was expected that high reinvestors would show reduced anticipatory accuracy and/or speed.

The element of deception researched in Study 3 provoked interest in a different form of deception from both the attacking and defensive coaches. The use of decoy runners is unique in the deception literature to date as it centres on players who are not in possession of the ball. This tactic involves multiple players in an attacking team who run option lines off the ball carrier, making it possible that any of the players could receive the ball. Runners who do not receive the ball are decoys and are used to confuse defenders about which attacker will receive the ball. Rugby coaches are often interested in what characteristics these decoy runners should display to maximise their deceptive potential (i.e., force defenders into indecision

by believing a decoy runner is receiving the ball). Therefore, in Study 4 (Chapter 5), an observational analysis of decoy runners efficacy was carried out. Based on the coaches' experiences it was expected that decoy runners would be most effective when they displayed characteristics that indicated they would actually receive the ball.

Study 5 (Chapter 6) was conducted in an attempt to explain the results observed in Study 4. In this final study, novice and expert rugby players viewed recreated plays involving decoy runners - from a defender's perspective - which were occluded before the ball was caught by the actual receiver. While viewing these plays, participants concurrently completed a rugby relevant low-demanding attention task or high-demanding attention task. At the cessation of the play, participants were required to indicate the exact position of the players when occlusion occurred. Of particular interest was whether increasing the attention demands that the defenders experienced caused performance decrements (e.g., failing to observe the player who received the ball). These findings were discussed in the context of the inattention blindness paradigm.

In the final chapter (Chapter 7), the findings are summarised and discussed with regard to relevant research in the decision making field. Practical applications for coaches are provided and future directions for research are considered.



## Chapter 2

### Experiment 1: Pattern recall, decision making and talent identification in rugby union<sup>1</sup>

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#### Abstract

The ability to make fast, accurate decisions is an essential skill for all who play sport. However, measuring this ability has proved difficult for coaches and talent identification practitioners. Pattern recognition (a key factor in decision making) has commonly been measured using pattern recall tasks. This study aimed to understand whether accuracy when recalling rugby union patterns is a valid measure of on-field decision making performance. In Study 1, professional players recalled structured patterns of players from still images (N=20) viewed for 5 seconds. On-field decision making markers, including coaches' rankings of decision making ability, playing position, number of years playing professionally and total number of years playing rugby union, were used as predictor variables of recall accuracy. Results showed that only total number of years playing rugby union was correlated with recall accuracy, suggesting that caution is necessary when adopting these tasks for talent identification purposes. The structured stimuli used in Study 1 were not representative of a true rugby union game, so Study 2 tested novice and expert players on a pattern recall task that included structured, semi-structured and unstructured rugby union patterns. Experts were significantly more accurate than novices when recalling structured and semi-structured patterns; however, there were no differences when recalling unstructured patterns. It was concluded that structured and semi-structured patterns should be used in future studies to test whether pattern recall tasks can be used for talent identification in rugby union.

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<sup>1</sup> Based on: Sherwood, S., Smith, T., & Masters, R. S. W. (2018). Pattern recall, decision making and talent identification in rugby union. *European Journal of Sport Science*, 1-8.

## **Introduction**

Talent identification (TI) requires the identification of individuals with the potential to excel in a particular sport (Vaeyens, Lenoir, Williams, & Philippaerts, 2008). Identifying individuals with appropriate physical characteristics, such as speed or aerobic fitness, can be done with relative ease using objective tests. However, appropriate tests to measure components of decision making ability, such as pattern recognition, have continued to elude practitioners.

Typically, assessment of decision making ability in potentially talented individuals is conducted by TI practitioners viewing a small number of performances while making subjective assumptions based on intuition rather than objective criteria (Williams, 2000). Following this, the individuals deemed to be most talented are usually invited to train or play in trial matches to allow coaches to pass expert judgment on them. Again, this process is highly subjective.

The ability to recognise patterns is an essential skill for rugby union players (Hendricks, 2012) and is a major component of decision making and anticipation (Farrow et al., 2010). To measure this perceptual-cognitive skill, pattern recall tasks have been adopted, which require participants to recall the positioning of teammates and/or opponents. These tasks have been widely used in sports, such as chess (de Groot, 1965; Chase & Simon, 1973), basketball (Allard et al., 1980; Gorman et al., 2011), soccer (Williams et al., 1993) and rugby union (Farrow et al., 2010). Studies have ascertained that experts possess greater ability to recognize or recall domain specific patterns of play (Gorman et al., 2011, Gorman et al., 2012; Williams, Hodges, North, & Barton, 2006), although experts typically only display superiority over less skilled counterparts when observing structured patterns of play; novices and experts are similarly skilled at recalling or recognizing unstructured patterns of play (Williams et al., 1993; Chase & Simon, 1973; Allard et al., 1980; Smeeton et al., 2004).

Raab and Farrow (2015) defined pattern recall as “the capacity to memorize specific structured situations or patterns from previous experiences, such as chess openings or attack formations in sport” (p. 513). An important consideration that is frequently

raised, questions the ecological validity of pattern recall tasks, as they fail to incorporate a movement skill and recalling players' positions is not a core requirement of performance (Williams & Ericsson, 2005). However, researchers typically adopt these tasks as they believe pattern recall facilitates anticipation and decision making. Farrow et al. (2010) found that pattern recall accuracy can explain up to 40% of the variance in performance on an anticipation task. Furthermore, it is believed that athletes make appropriate decisions based upon the dynamic positioning of teammates and opponents (Farrow et al., 2010; Gorman et al., 2012, 2013; Williams & Davids, 1995).

To date, only one study (van Maarseveen et al., 2016) has researched the relationship between performance on pattern recall tasks and decision making performance in-situ. van Maarseveen et al (2016) found that in-situ performance of talented female soccer players was not predicted by performance on pattern recall tasks, suggesting that caution is necessary when adopting these tasks for TI purposes. The current studies aimed to clarify the relationship between pattern recall performance and on-field performance in elite rugby union players. To do this, a rugby union specific pattern recall task was completed by professional players. A number of predictor variables – including total number of years playing rugby union, number of years playing rugby union professionally and coach rankings of decision making ability were collected – with accuracy scores from the pattern recall task used as the dependent variable. Due to the differences in positional requirements (e.g., a prop may only touch the ball twice in a whole game), we believe that a notational analysis would fail to encapsulate the decision making abilities of some players. As such, the coach's perception of the player after sustained observations (one year plus) was adopted as the gold standard for assessing decision making ability in this investigation.

## **Study 1**

### **Method**

#### *Participants*

Fifty-seven elite male rugby union players (age  $22.63 \pm 3.14$  years) with an average of  $3.54 \pm 2.6$  years of professional experience were recruited to take part in the study. Players were recruited from the top two leagues in New Zealand. Ethical approval was obtained from a university panel and all participants provided informed consent prior to involvement.

#### *Test images*

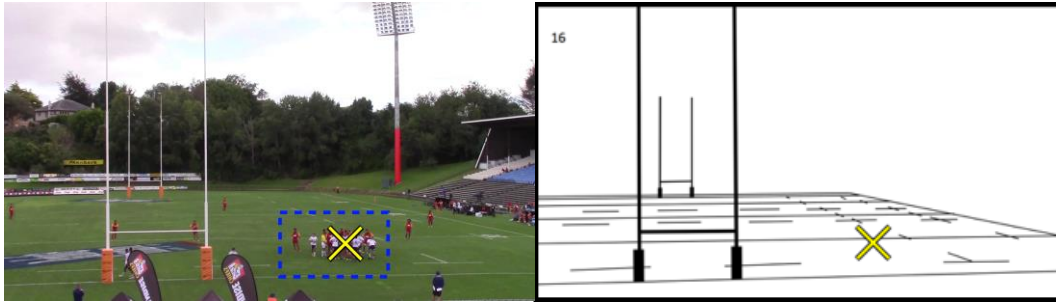
Still images ( $N = 55$ ) were collected, via screenshots of a video feed, from a match between two Super Rugby under 20 teams. Static, as opposed to dynamic, images were adopted on the basis of research by Gorman et al (2012), which suggested that there was no significant difference in experts' recall accuracy when comparing static against dynamic stimuli. Static images were favoured as they were considered to be easier for TI practitioners to adopt. 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), 5m 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 et al, 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 categorised as open play ( $N = 10$ ), lineout ( $N = 5$ ) or scrum ( $N = 5$ ). Participants were not required to recall the position of players involved in the lineout or scrum. Images were also categorised as a defensive pattern ( $N=9$ ) or an attacking pattern ( $N=11$ ), from the participant's perspective.

### *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 secs 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 Figure 4). This ensured that the number of players recalled was equivalent across all stimuli.

### *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 (1430 x 808 pixels) - with only the pitch markings, post location and reference point displayed (Figure 4 - 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 x 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 accurately as possible. For consistency, participants were instructed to use the cell where the player's feet were touching the ground. Participants could change the location of their chosen positions by deleting and repositioning the Xs within the cells.



**Figure 4.** Test stimuli (left) recall sheet (right)

Participants were asked to indicate the number of years during which they had played rugby union (at any level), how many years they had played professionally and their usual position. To understand whether pattern recall tasks can be used as a screening tool, world-renowned coaches (who had coached the participants for at least 1 year) were asked to rate each player with regard to their general decision making ability and how well they ‘read the game’, in both attack and defence. Reading the game requires a player to search for or identify significant characteristics of patterns to act upon (Greenwood, 2015). Reading the game is a common term used by elite coaches; however, we provided an example, ‘how well do they [players] identify space to attack?’, to provide an example of what reading the game can relate to. Three coaches rated each participant on a Likert scale ranging from 1 to 10, with 10 being excellent. This was a bespoke scale created for the current investigation.

#### *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. 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 et al (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. The analysis method used in the current study was considered to be the best measure as it reduced these instances and it was also seen as more representative of the perceptual-cognitive skills required in rugby union 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 when the attacking team has an additional player compared to the defensive team (e.g., 4 attacking players against 3 defending players). 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.

Excel formulas were embedded into the document to calculate the distance between the coordinates of the participant's chosen locations ( $x_1$  and  $y_1$ ) and the actual locations of the players ( $x_2$  and  $y_2$ ). Pythagoras' Theorem ( $\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$ ) was used to determine these distances; 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.

SPSS (Version 24, IBM, UK) was used to conduct the analysis. The independent variables were the number of years playing rugby union at any level (Years Playing), the number of years playing rugby union professionally (Years Professional) and the player's usual position (Position). The dependent variable was the average accuracy score out of 6 (Accuracy). As an initial validation, and to understand the relevance of the task, Spearman's Rho correlations between individual characteristics (Years Playing and Years Professional) and accuracy scores was examined.

Further analyses were implemented to test for differences in recall accuracy as a function of playing position, dependent upon stimuli type. To do this, participants were first coded as either a Back (player not involved in the scrum) or a Forward

(player involved in the scrum), before being further categorised into 1 of 5 positional groups. Participants were coded as a Tight Forward (Props, Hooker and Locks), Loose Forward (Flankers and Number 8), Inside Back (Scrum half and Fly half), Midfield Back (Inside Centre and Outside Centre) or Outside Back (Wings and Fullback). Accuracy on the different stimuli types (Scrum Accuracy vs Lineout Accuracy vs Open Play Accuracy) made up the dependent variables. As forwards are always involved in the scrum, and often involved in the lineout, it was hypothesized that backs would display more accurate recall of scrum and lineout patterns. However, as both forwards and backs experience open play equally, recall accuracy was expected to be similar. To examine any differences, a 2 (Back vs Forward) x 5 (Tight Forward vs Loose Forward vs Inside Back vs Midfield Back vs Outside Back) x 3 (Scrum Accuracy vs Lineout Accuracy vs Open Play Accuracy) repeated measures ANOVA was conducted.

The primary measure used to determine whether pattern recall tasks can be used to assess on-field decision making performance, was the relationship between Accuracy and the coaches' perception of the player's on-field decision making. Pearson product-moment correlation coefficients were computed using Accuracy, Attack Accuracy (average accuracy on attacking patterns) and Defence Accuracy (average accuracy on defensive patterns) as the dependent variables. The coach's ranking of the player's Decision Making (in attack, defence and an average of both) and how well they Read the Game (in attack, defence and an average of both) formed the independent variables.

## **Results**

Due to violations of homogeneity, Spearman's Rho correlation tests were carried out between Years Playing, Years Professional and Accuracy. Results showed that Years Playing was significantly positively associated with Accuracy ( $r_s = 0.323$ ,  $p < 0.05$ ). Years Professional, however, was not significantly correlated with Accuracy ( $p > 0.05$ ).

The 2 (Back vs Forward) x 5 (Tight Forward vs Loose Forward vs Inside Back vs Midfield Back vs Outside Back) x 3 (Scrum Accuracy vs Lineout Accuracy vs Open



Play Accuracy) ANOVA failed to reveal any significant interactions or main effects for playing position and accuracy scores ( $ps > 0.05$ ). Furthermore, it was hypothesized that backs would display better recall accuracy for scrum and lineout stimuli, with equivalent accuracy for open play stimuli, when compared to forwards. The ANOVA suggested there were no differences between accuracy scores on the different stimuli types, both generally and by playing position ( $ps > 0.05$ ).

In the current investigation, the gold standard measure of the recall test's validity was the correlation between a player's accuracy scores and a coach's perception of their on-field performance. Multiple Pearson product-moment correlation coefficients were computed between the Accuracy scores and the coach perception measures. The results showed no significant correlations between coach perceptions and player scores in the recall task ( $ps > 0.05$ ). These correlations are shown in Table 1.

**Table 1.** R values of the Pearson product-moment correlations between the coach's perception of player's decision making and the player's recall accuracy (\* denotes a significant correlation)

	Accuracy (All)	Accuracy (Attack)	Accuracy (Defence)
Decision Making (Attack)	0.061	0.079	0.016
Decision Making (Defence)	-0.059	0.002	-0.201
Decision Making (Average)	-0.005	0.040	-0.113
Read the Game (Attack)	-0.050	0.014	-0.153
Read the Game (Defence)	0.120	0.127	0.079
Read the Game (Average)	0.049	0.087	-0.030

## **Discussion**

The need for more objective measures of talent identification has been frequently highlighted in previous research, especially for perceptual-cognitive abilities (Williams, 2000). Pattern recall methodologies have been widely used in sport and have been shown to predict performance in anticipation tasks (Farrow et al., 2010). However, the relationship between pattern recall and on-field performance is ambiguous, so the inclusion of these tasks in talent identification procedures warrants caution.

It was shown that players with more years of experience (total years playing rugby union) displayed more accurate recall than players with less experience. Raab and Farrow (2015) argued that pattern recall ability improves over the course of sporting development. Our results suggest that pattern recall skills continue to improve, even for elite performers. This can be explained by the template theory proposed by Gobet and Simon (1996), which suggests that through exposure and practice experts develop templates of typical structures experienced in game based scenarios. These templates are stored in long-term memory and accessed for performance and when performing recall tasks, as in the current investigation. Chunking theory (Chase & Simon, 1973; Borgeaud & Abernethy, 1987; Allard et al, 1980; Gorman et al, 2012) has been frequently used to explain experts' superior recall compared to non-experts. The chunking theory suggests that the expert's superiority is not due to enhanced memory capacity but rather to an encoding mechanism. Experts are thought to group large amounts of information as a single entity or 'chunk'. This mechanism avoids the usual restrictions of short-term memory (Chase & Simon, 1973; Brylinsky, 2010). Our results suggest that experts with more years' experience may have developed a larger repertoire of chunks and templates to aid encoding and retrieval of the information viewed.

The pattern recall task used in Study 1 may not be a valid tool for TI purposes, as it did not predict on-field performance. Comments from players suggested that the stimuli used did not fully represent the chaotic nature of the sport. Therefore, one

explanation for why pattern recall accuracy scores were not correlated with the measures of decision making ability could be that decisions are often based on unstructured or transitional patterns of play. A transitional pattern refers to instances when the team in possession transitions from attack to defence. During this period, patterns can change from unstructured to semi-structured before becoming structured. McKay (2012 – unpublished findings) found that 57% of possession in rugby union is gained from unstructured sources, such as turnovers, kicks or knock-ons. This finding suggests that the majority of decisions are not based on structured stimuli, which the current study solely used.

## **Study 2**

Chase and Simon (1973) showed that experts were significantly more accurate than novices when recalling structured patterns in chess, but there was no difference between novices and experts when recalling unstructured (random) arrays of chess pieces. Research by Allard et al (1980), Borgeaud and Abernethy (1987), Williams et al (1993) and Gorman et al (2011) showed the same findings with respect to experts and novices in sport. However, McKay (2012) suggested that during rugby union games there are many transitions from attack to defence during which decisions are based on semi-structured patterns of players. Consequently, a potential limitation of Study 1 was that the range of stimuli that we used might not have been representative of a true rugby union game. Therefore, in Study 2 we examined pattern recall across a wider range of rugby scenarios. Novice and expert rugby union players were asked to recall the position of players in not only structured game scenarios, but in semi-structured and unstructured game scenarios also. By including these scenarios, we sought to understand if rugby union experts outperform novices on all stimuli types or if their superiority is confined to structured stimuli, as shown in previous studies (Chase & Simon, 1973; Allard et al, 1980; Williams et al., 1993; Smeeton et al., 2004). Experts displaying enhanced recall accuracy for semi-structured or unstructured scenarios, compared to novices, would suggest that decisions are often based on such patterns. This finding would warrant the inclusion of such stimuli in future research focusing on pattern recall tasks in rugby union, to create a more representative measure.

## **Method**

### *Participants*

A novice group ( $N = 41$ ) was formed of university students (age  $18.9 \pm 1.32$  years) with less than two years rugby union playing experience, at no higher than a recreational level. An expert group ( $N = 47$ ) was recruited from a Super Rugby team's under 18 development squad (age  $17.23 \pm 0.65$  years; mean  $\pm$  SD). The players in the squad had an average of  $9.17 \pm 2.76$  years playing experience. Ethical approval was obtained from a university panel and all participants provided informed consent prior to involvement.

### *Test images*

Images were taken from the original bank of 55 images used in Study 1. Ten structured images (rated 8-10 by coaches) were combined with six semi-structured images (rated 3-4 by coaches) and four unstructured images (rated 1-2 by coaches). Images rated 3-4 by coaches were categorised as semi-structured, as pilot testing suggested that they were most representative of transitional periods of play. The stimuli were randomly ordered to create the recall test.

### *Test procedure*

The procedure mimicked Study 1 – participants viewed the stimuli for 5 seconds before occlusion and were required to recall the position of 6 players playing towards the camera on a blank template as accurately as possible. The only difference was the inclusion of unstructured and semi-structured stimuli.

### *Data analysis*

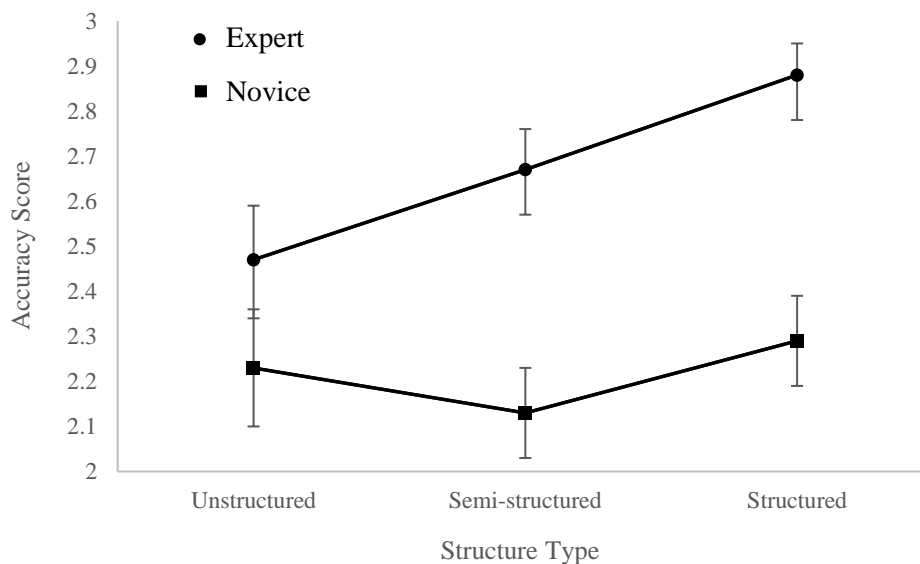
Accuracy was scored identically to Study 1. That is, average scores (out of 6) from each structure type were calculated for statistical analysis. A 2 (Expert vs Novice) x 3 (Unstructured vs Semi-structured vs Structured) mixed design ANOVA was conducted to examine recall differences. Separate one-way repeated measures ANOVAs (one for experts and one for novices) were completed to examine

differences in recall accuracy on the different stimuli types. Three independent samples t-tests were also completed to compare expert and novice scores on the different stimuli types.

## Results

The ANOVA revealed a statistically significant interaction between skill level and the 3 structure types ( $F(2,174) = 4.508, p < 0.05$ ). Follow up one-way repeated measures ANOVAs showed no differences in novice recall scores for structure type ( $p > 0.05$ ). Expert participants, however, showed significantly higher recall scores for Structured stimuli compared to Semi-structured stimuli ( $p < 0.05$ ) and Unstructured stimuli ( $p < 0.001$ ), and for Semi-structured stimuli compared to Unstructured stimuli ( $p = 0.05$ ). The mean and standard deviation of recall accuracy for each stimulus type is shown in Figure 5.

Between subject comparisons, in the form of t-tests, revealed significant differences between novice and expert recall scores in Semi-structured ( $p < 0.001$ ) and Structured ( $p < 0.001$ ) stimuli; however, there was no significant difference between novices and experts in Unstructured stimuli ( $p > 0.05$ ).



**Figure 5.** Mean accuracy scores for recall of patterns with different structure types ( $\pm$  standard error bars)

## Discussion

In Study 2, we adopted a method similar to the historical protocol used by Chase and Simon (1973) in order to understand if a wider range of stimuli needed to be used in future TI pattern recall tasks for rugby union. Expert and novice participants were required to recall the positions of players in structured, unstructured and, unlike Chase and Simon's study, semi-structured stimuli.

As in previous studies (Williams et al., 1993; Chase & Simon, 1973; Allard et al, 1980; Smeeton et al., 2004), expert and novice recall of unstructured stimuli was equivalent. This suggests that experts were unable to create templates, or chunk the information, in these stimuli because there were no patterns. Experts' enhanced recall of structured stimuli is consistent with previous research, as templates and chunks can easily be utilized for recall of patterns available in structured stimuli. The significant difference uncovered between experts' and novices' recall accuracy on semi-structured stimuli is an interesting development. In fast-paced sports, such as rugby union, structured patterns are likely to emerge dynamically (and in subtle ways) from unstructured situations (e.g., as players reorganize themselves into standard positions on the field). Previous research has shown that experts use anticipatory encoding processes in recall tasks, which allows them to instinctively predict where players will be located, rather than extrapolating from their current positioning (Gorman et al, 2012). Gorman et (2012) showed that experts encoded the future locations of basketball players more accurately than novices, despite being instructed to recall only the player's final location before occlusion. In the current study, experts may have utilized anticipatory encoding processes to forecast the structured position that players were reorganizing into and then used that information to enhance recall accuracy. It seems unlikely, however, that experts were able to utilize anticipatory encoding processes for unstructured situations, as players may not have begun to reorganize into structured positions.

Although completing the procedure on Excel created a quick, user-friendly platform for the recall task, it was a limitation in the current investigation. The size of the cells (5 pixels squared) led to increased real-world error for players most distal from the viewer's perspective. The 6-cell radius for correct answers was

approximately 1 meter for the near try line compared to approximately 2.4 meters for the far try line. Future research may look to use software that compares pixel location to real world coordinates, as used by van Maarseveen et al (2015) to test the reliability of the current findings. A further limitation was the presence of players in the images who were not to be recalled (i.e., the players located within the blue boxes). This may have been a limitation as it may have broken up the pattern, which would have disrupted recall in cases where participants had ‘chunked’ players’ positions relative to players within the blue boxes. However, it was felt that edited stimuli from real games was more realistic than artificially created training scenarios with only the correct number of players involved (for example 3 vs 3 football scenarios in van Maarseveen et al’s, 2015, study). Further research may be needed to validate this methodology.

The results from the current investigation support the claim made by van Maarseveen et al (2016) that pattern recall tasks may not warrant inclusion within talent identification protocols. However, future research should seek to clarify whether more representative stimuli (structured and semi-structured) reveal stronger comparisons with on-field rugby union performance. Although it was suggested that a notational analysis of on-field performance wouldn’t represent the full decision making responsibilities in rugby union, pattern recall scores should be compared to performance in other sports where notational analysis methods are more sophisticated and valid.

## Chapter 3

### Experiment 2: Decision reinvestment, pattern recall and decision making in rugby union<sup>2</sup>

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The findings from Chapter 2 revealed that pattern recall tasks did not differentiate experts based on their decision making ability. However, experts with more years of playing experience displayed better performance on the task. Also, experts were significantly more accurate than novices when recalling semi-structured and structured patterns. As mentioned in the introduction, the Theory of Reinvestment has been linked to performance decrements in motor and decision skills under pressure. To date, the propensity for reinvestment has not been researched with regards to pattern recall ability. Therefore, in Chapter 3 the propensity for reinvesting conscious knowledge when making decisions (measured using the DSRS) was examined with respect to pattern recall accuracy and, unlike Experiment 1, recall speed.

#### **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 five seconds 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

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<sup>2</sup> Based on: Sherwood, S. M., Smith, T. B., & Masters, R. S. W. (2019). Decision reinvestment, pattern recall and decision making in rugby union. *Psychology of Sport and Exercise*, 43, 226-232.



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.

## **Introduction**

Effective decision-making is crucial in sport; so much so, that McMorris (2004) and Royal, Farrow, Mujika, Halson, Pyne, and Abernethy (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 et al., 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 et al., 2012). Pattern recall tasks have been developed to test this perceptual-cognitive skill and have been used in sports such as basketball (Gorman et al., 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 five second 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 et al (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 et al., 2003; Jackson et al., 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 et al (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 et al, 2015), netball (Jackson et al., 2013) and korfbal (Kinrade et al., 2010). Additionally, higher DSRS scores have also been

associated with impaired decision making and bias under pressure in netball umpires (Burnett et al., 2017) and football referees (Poolton et al., 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 et al., 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 seconds 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.

## **Study 1**

### **Method**

#### *Participants*

Fifty-seven elite male rugby union players (age  $22.63 \pm 3.14$  years) with an average of  $3.54 \pm 2.6$  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.

#### *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), 5m 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 et al., 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.

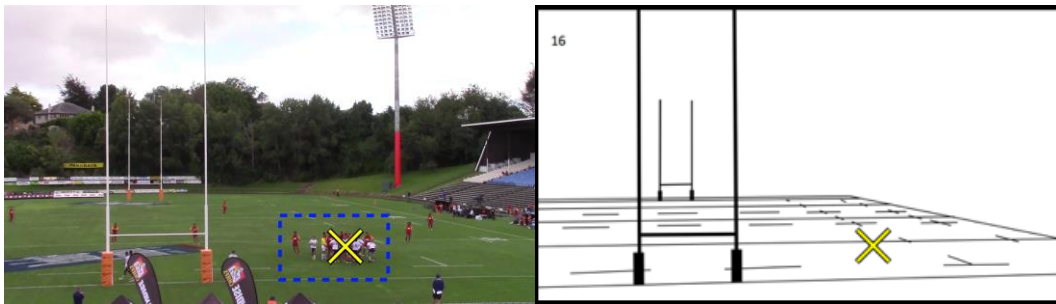
### *Test procedure*

Participants' viewed the still image of a rugby union scenario presented by a projector (Panasonic, CW230, Japan). The still image was presented for 5 secs 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 Figure 6). This ensured that the number of players recalled was equivalent across all stimuli.

### *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 (Figure 6 - 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 x 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 change the location of their chosen positions by deleting and repositioning 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.



**Figure 6.** Test stimuli (left) recall sheet (right)

To calculate the distance between the coordinates of the participant's chosen locations ( $x_1$  and  $y_1$ ) and the actual locations of the players ( $x_2$  and  $y_2$ ). 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”. This scale was completed after the recall procedure to avoid any potential interference with the task.

### *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 et al (1980) and Abernethy et al (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,

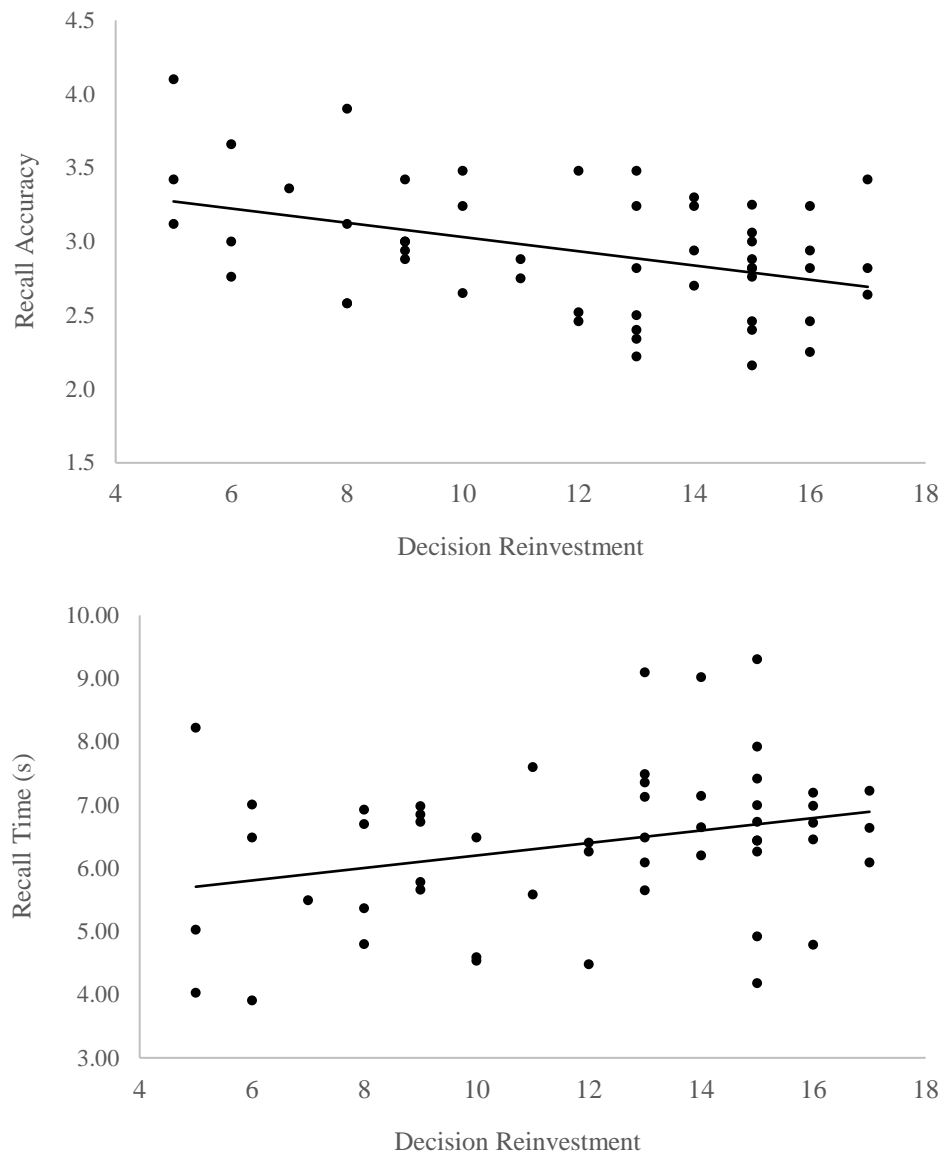
California). A tone sounded at the point of occlusion, signifying the start of recall. Software (iMovie - Apple, Version 10.1.6, California) was used to measure the time between the tone and the moment at which the last player's position was entered. An average of each participant's recall times was 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).

## **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 seconds ( $SD = 1.22$ , range = 5.4 seconds). Furthermore, there were no significant differences in Recall Accuracy or Recall Time between the stimuli ( $p > 0.05$ ). Additionally, recall accuracy did not differ by individual players in each stimulus ( $p > 0.05$ ). Spearman's Rho coefficients revealed that there was no association between Global Reinvestment and Recall Accuracy ( $r = -.225$ ,  $p = .106$ ). Global Reinvestment was, however, significantly positively associated with Recall Time ( $r = .366$ ,  $p = .007$ ), 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 ( $r = .289$ ,  $p = .036$ ), with higher scores on the scale associated with slower recall (see Figure 7). No significant correlations were found between Rumination, Recall Accuracy ( $r = -.003$ ,  $p = .983$ ) or Recall Time ( $r = .181$ ,  $p = .194$ ).



**Figure 7.** Correlations between Decision Reinvestment, Recall Accuracy and Recall Time (s)

## 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 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, Furley et al., 2010; Gorman et al., 2013; 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., 2007; 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 (<1000ms) 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 4030-9306ms); 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.

## **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 (50ms), 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<sup>3</sup> condition participants were required to recall a specified half of the players first before recalling the

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<sup>3</sup> The current study used the term ‘constrained report’ as a slight variation on Sperling’s (1960) partial report procedure.

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.

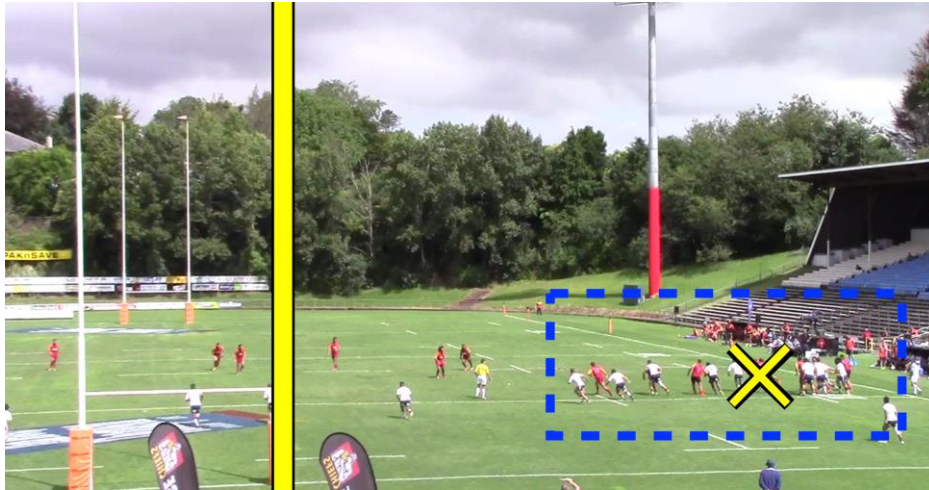
## **Method**

### *Participants*

Forty-one highly skilled male rugby players (age  $17.07 \pm 0.64$  years) with an average of  $9.17 \pm 2.76$  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.

### *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 (Figure 8).



**Figure 8.** Study 2 test stimuli

### *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 1-6 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.

### *Test procedure*

As in Study 1, participants viewed each stimulus for 5 seconds 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

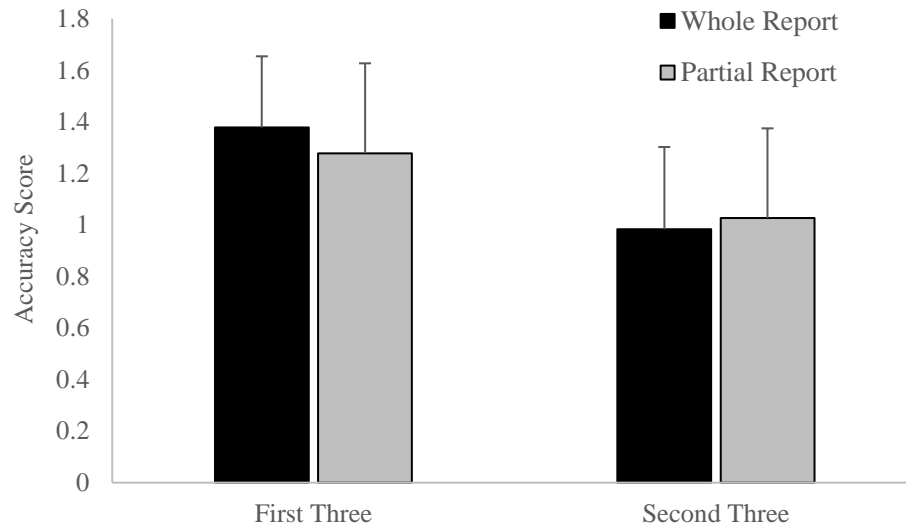
each participant. When all the trials had been completed, participants completed the DSRS.

### *Data analysis*

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

## **Results**

The initial ANOVA showed a main effect for Order of Recall ( $F(1,40) = 10.424$ ,  $p = 0.002$ ,  $\eta_p^2 = 0.207$ ), 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 ( $p > 0.05$ ) and there was also no significant interaction between Order of Recall and Recall Strategy ( $p > 0.05$ ). These results are shown below in Figure 9. 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.



**Figure 9.** Average accuracy scores for the First Three and Second Three recalled in the Whole Report and Constrained Report conditions, with standard deviation bars

## 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 666ms) 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).

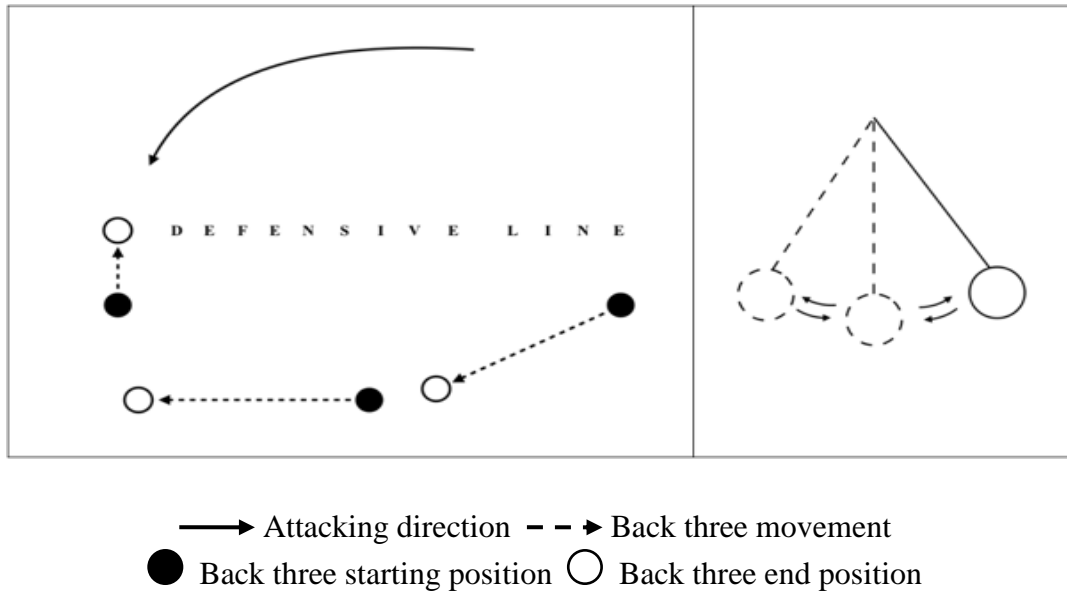
## **General Discussion**

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. They 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 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 et al., 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 (Masters, 2000; 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, fullback) 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 Figure 10).





**Figure 10.** Example of a back three working as a ‘pendulum’ (left) and a ball swinging pendulum (Newton’s cradle - right)

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).

## Chapter 4

### Experiment 3: Anticipating deceptive movements in rugby union: The role of reinvestment<sup>4</sup>

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Chapter 3 reported evidence suggesting that the propensity to reinvest highly about decisions can cause slower recall of structured patterns and poorer recall accuracy. These findings were explained primarily using Decay Theory, with slower recall (caused by reinvestment) leading to poorer recall accuracy as the memory trace of the players' position decayed. This research is novel, as the effect of reinvestment has not been previously investigated with regards to pattern recall ability. Similarly, the role of reinvestment in anticipation of deceptive movements has not been examined in previous research. This provides the rationale for Chapter 4, in which the primary aim was to examine how movement and decision reinvestment affects the anticipation of deceptive and non-deceptive changes of direction in rugby union. The secondary aim of the study was to replicate previous research, which examined skill level differences in anticipation of deceptive movements.

#### **Abstract**

The ability to quickly and accurately anticipate deceptive and non-deceptive movements is crucial in many sports. In the current investigation, novice (N=10), intermediate (N=10) and professional (N=10) rugby players anticipated the final running direction of an opponent changing direction (with or without deception). The study aimed to better understand (1) the effect skill level has on anticipation of deceptive and non-deceptive movements and (2) whether the propensity for reinvestment plays a role in anticipatory performance. Reinvestment is an individual predisposition to consciously monitor and control decisions (measured

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<sup>4</sup> Based on: Sherwood, S. M., Smith, T. B., & Masters, R. S. W. (under review). Anticipating deceptive movements in rugby union: The role of reinvestment. *The Journal of Sport and Exercise Science New Zealand*

using the Decision Specific Reinvestment Scale) or movements (measured using the Movement Specific Reinvestment Scale). Much research has shown that the tendency to reinvest detrimentally affects performance under pressure. Our results showed that expert players took significantly longer to respond compared to novices and were significantly more accurate than novices when anticipating deceptive and non-deceptive changes of direction. Furthermore, Conscious Motor Processing (a subscale of the Movement Specific Reinvestment Scale) was associated with poorer accuracy when responding to deceptive changes of direction. The findings are discussed based on previous research in the field.

## **Introduction**

In fast paced sports, decisions are seldom made on the basis of reliable (high certainty) information alone. Performers therefore need to make decisions based upon anticipation of what is likely to occur. For example, Chang and Yang (2011) calculated that when facing a fast serve in tennis (over 200km/h), players have 500-700ms before they have to return the ball. They have a very small window in which to a) judge the ball's direction and speed, b) decide on an appropriate shot, c) move into the right position and d) prepare and execute the required shot. Responding based purely on the flight of the ball (reliable information) is inadequate because human sensory processing speeds are too slow (Loffing & Cañal-Bruland, 2017). Consequently, expert performers utilize advanced information from the server's kinematics to anticipate the shot direction or location (Farrow, Abernethy, & Jackson, 2005).

The ability to anticipate the behaviours of an opponent has been shown to discriminate between experts and non-experts in many sports, including squash (Howarth, Walsh, Abernethy, & Snyder, 1984), tennis (Singer, Cauraugh, Chen, Steinberg, & Frehlich, 1996), rugby (Jackson et al, 2006) and badminton (Wright, Bishop, Jackson, & Abernethy, 2011). To measure an individual's ability to anticipate effectively, temporal occlusion methodologies are often utilised. These involve termination of observed sequences of movement at various times to remove advanced and/or reliable information. Occlusion before reliable information is

available (e.g., racket contact in tennis) forces performers to make decisions based on advanced information only.

Anticipation is more complex when a player uses deception to mislead an opponent into making an incorrect decision (see Güldenpenning, Steinke, Koester, & Schack, 2017, for a review). Research has shown that anticipation is worse for deceptive compared to non-deceptive movements (e.g., Mori & Shimada, 2013; Dicks et al., 2010; Jackson et al., 2006). Both Mori and Shimada (2013) and Jackson et al (2006) demonstrated that novices were more susceptible to deceptive movements than experts, showing significant decreases in the accuracy of their responses. Anticipation of deceptive actions by experts is thought to be superior to novices because they have greater experience in both perceiving and performing the observed actions (Cañal-Bruland et al., 2010). Aglioti et al (2008), for instance, found that experienced basketball players could predict the outcome of a shot when they only saw body kinematics, whereas, journalists with experience of watching, but not playing, basketball needed to see the ball trajectory to successfully anticipate shot outcome.

Anticipation may also be affected by mental functions. The theory of reinvestment (Masters, 1992; Masters & Maxwell, 2008) proposes that there are individual differences in the extent to which people consciously or non-consciously monitor and control their behaviours. Movement specific reinvestment (Masters, 1992; Masters et al., 2005) refers an individual's propensity to draw upon (and reinvest) previously acquired explicit, rule-based knowledge to consciously control movements. Whereas, decision specific reinvestment (Kinrade et al., 2010) refers to an individual's propensity to consciously monitor and control decision making processes. Research in the motor domain has generally shown that individuals with a high disposition for movement specific reinvestment (measured using the Reinvestment Scale or the Movement Specific Reinvestment Scale; MSRS), see Masters & Maxwell, 2008) are more likely to experience performance breakdown under pressure (e.g., Law, Masters, Bray, Eves, & Bardswell, 2003; Liao & Masters, 2001; Masters et al., 1993; Schücker, Ebbing, & Hagemann, 2010). Research has also shown that high decision reinvestors (measured using the Decision Specific Reinvestment Scale; DSRS), Kinrade et al., 2010) make slower

and/or less accurate decisions under pressure. This has been shown in sports such as basketball (Kinrade et al., 2015), netball (Jackson et al., 2013) and korfbal (Kinrade et al., 2010). It has been suggested that reinvestment causes performance decrements under pressure because previously automated processes are broken down into separate units, as in the early stages of learning, which increases the opportunities for disruption (Beilock & Carr, 2001; Masters, 1992).

In rugby, a ball carrier will often perform a side-step to mislead a defensive counterpart into making an ineffective tackle. For example, Wheeler et al (2010) showed that 72% of tackle breaks were a result of an attacker side-stepping the defensive player. To date, the association between propensity for reinvestment and anticipation of deceptive movements has not been examined. Therefore, in the current study, expert, intermediate and novice rugby players were required to anticipate the final running direction of players changing direction using a side-step, (i.e., deceptive movements to provide misleading kinematic information about their intentions) or using non-deceptive movements. We asked whether a higher propensity for reinvestment (movement or decision) causes slower or less accurate anticipation in response to deceptive side-steps in rugby? We also examined the role of skill level in this process.

## **Method**

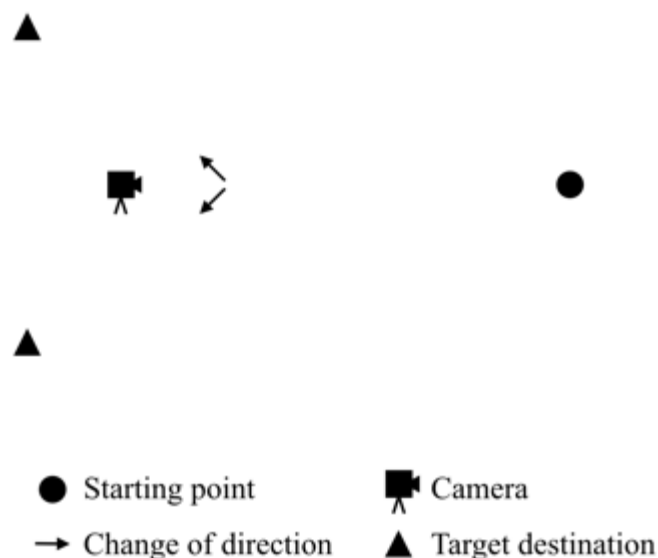
### *Participants*

A novice group (N=10) was formed of participants with less than two years of rugby union playing experience, at no higher than a recreational level (age  $22.4 \pm 4.69$  years). An intermediate group (N=10) was formed of participants with at least two years of club level experience (average 9.1 years), but no professional playing experience (age  $22.8 \pm 4.23$  years). An expert group (N=10) was formed of professional players from the top two leagues in New Zealand, with an average of 16.6 years playing experience (age  $23.7 \pm 2.49$  years). Ethical approval was obtained from a university panel and all participants provided informed consent prior to involvement.

### *Test trials*

The experimental task represented a ‘one-on-one’ tackle situation in rugby (c.f. Jackson et al, 2006), with participants assuming the role of a defending player tasked to prevent the attacking player from progressing up-field. A major departure from other studies (i.e., Jackson et al, 2006) was that the tackle situations were filmed using a 360° camera, in order that they could be viewed in virtual reality. Following technological advancements in recent years, virtual reality has become increasingly popular to mirror real life scenarios more closely (e.g., Bideau, Kulpa, Vignais, Brault, Multon, & Craig, 2010; Stinson & Bowman, 2014).

Two highly skilled rugby players were used to create the tackle scenarios. Players were filmed using a 360° camera (Ricoh Theta V, Japan) on a tripod at a height of 1.5m. Players ran towards the camera, from a starting point at a distance of 16m (see Figure 11). At a distance of 2m from the camera, players changed direction using either a deceptive change of direction (Deceptive Trials) or a non-deceptive change of direction (Non-Deceptive Trials). In Non-Deceptive trials, players changed direction towards one of two targets located at an angle of 45° (triangles below). In Deceptive Trials, players feinted towards one target before changing direction to run towards the other target. Players were filmed multiple times running to both the left and the right.



**Figure 11.** A visual representation of the filming set up used

Adobe Premiere Pro (Version 12.1, California) was used to edit each clip so that it occluded at one of three time points relative to the final foot contact prior to change of direction: t1 (-100ms), t2 (0ms) and t3 (+100ms). Figure 12 displays an example of the final frame before occlusion for each time point. All clips commenced with a 3-2-1 countdown and concluded with a black screen at occlusion for 2 seconds between trials. To facilitate response timing, a tone was inserted in each clip 3s before final foot contact prior to change of direction; response times less than 3 seconds indicated that participants responded prior to change of direction. A final bank of trials (N=120) was created, with Deceptive Trials (N=60) and Non-Deceptive Trials (N=60). Twenty of the Deceptive and Non-Deceptive trials were randomly occluded at each of the three time points.



**Figure 12.** The final frames of a non-deceptive trial occluded at T1 (left), T2 (middle) and T3 (right).

A block of practice trials and four blocks of experimental trials were created. The practice block consisted of 10 randomly selected clips that included deceptive trials (N=5) and non-deceptive trials (N=5). Each block of experimental trials consisted of 20 randomly selected clips that included deceptive trials (N=10) and non-deceptive trials (N=10). Trials were also counterbalanced by occlusion point and final running direction.

### *Test procedure*

Participants viewed each clip using a virtual reality (VR) headset (Gear VR, Samsung, South Korea). Viewing 360° footage through VR headsets allows observers to immerse themselves within the environment and has increased fidelity compared to viewing videos on flat surfaces, such as laptops or projectors. Prior to starting, participants completed a health questionnaire to ensure they would not experience negative symptoms from the VR headset. Participants also provided information about their age and rugby union experience (level and number of years), and completed the MSRS (Masters, et al., 2005) and the DSRS (Kinrade, et al., 2010). The MSRS assesses propensity for conscious monitoring and control of movements via questions that are categorised under two separate sub-scales: movement self-consciousness (an individual's propensity to monitor public perceptions of their style of moving) and conscious motor processing (an individual's propensity to consciously engage in controlling their movements). The DSRS assesses propensity for conscious monitoring and processing of decisions via questions that are also categorised under two separate subscales: 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). For both the MSRS and the DSRS, scores on each sub-scale can be computed or a global propensity score can be examined.

Participants first completed a block of practice trials before completing each block of experimental trials (allocated in a random order using a random sequence generator). All blocks were completed in one session (approx. 20 mins). In each trial, participants were asked to anticipate the final destination of the observed player as quickly and accurately as possible by providing a verbal response: "left" or "right". Participants were encouraged to stand in a position that they would typically adopt when defending and were allowed to accompany their verbal response with physical responses if they chose to. At the end of each block of trials, the VR headset was removed and participants rested for approximately 2 mins before proceeding to the next block of trials.



At the end of the procedure, participants were debriefed about the purpose of the study. They were also asked to estimate the realism footage to ascertain the fidelity of the methodology for future studies.

### *Data analysis*

Response accuracy and time were computed for deceptive and non-deceptive trials as a function of time of occlusion (i.e., -100ms, 0ms, +100ms). Response time was calculated using Audacity software (Version 2.3, Pennsylvania, USA) to identify the time that elapsed between the tone (3s before final foot contact at change of direction) and initiation of the verbal response (left/right). Scores on the MSRS and DSRS (and each subscale) were recorded.

Statistical analyses were completed using SPSS (Version 24, IBM, UK). Two 3 (Skill level: Novice/Intermediate/Expert) x 2 (Stimuli Type: Deceptive Trials/Non-Deceptive Trials) x 3 (Occlusion Point: -100ms/0ms/+100ms) mixed design ANOVAs were computed to examine response accuracy and response time. Post hoc analyses were completed where necessary.

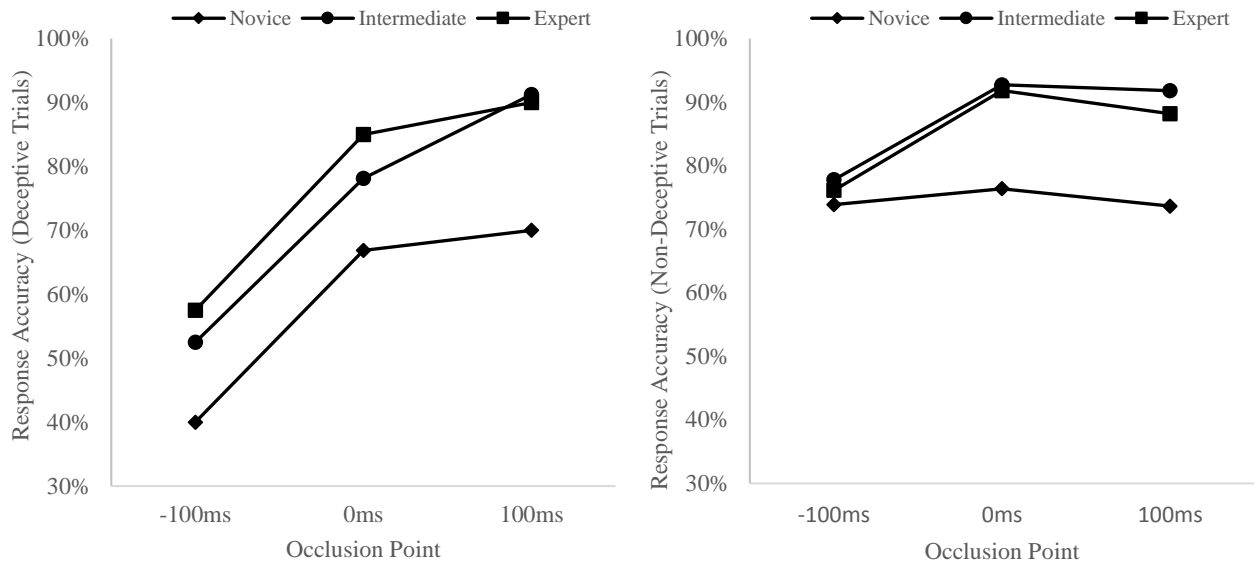
To examine the role of reinvestment in anticipation performance, hierarchical regression analyses were conducted for response accuracy on deceptive trials and non-deceptive trials (occluded at -100ms) and for response time on deceptive and non-deceptive trials (occluded at -100ms). Only trials occluded at -100ms were included as they were the only trials in which stepping information was completely unavailable (pure anticipation). In the first step of each regression analysis, skill level was accounted for by coding Novices, Intermediates and Experts as 1, 2 and 3, respectively. In the second step, the predictor variables MSRS Global (all questions), MSRS Self-Consciousness, MSRS Conscious Motor Processing, DSRS Global (all questions), DSRS Decision Reinvestment and DSRS Decision Rumination, were entered. A significant  $R^2$  change in the second model was considered an indication that reinvestment (one or multiple scores) had an effect on anticipation, regardless of skill level.

## Results

### *Response Accuracy*

The mean Response Accuracy scores for Deceptive and Non-Deceptive trials are shown in Figure 13. Main effects were evident for Stimulus Type ( $F(1,27) = 29.158$ ,  $p = 0.001$ ,  $\eta_p^2 = 0.519$ ), Occlusion Point ( $F(2,54) = 39.952$ ,  $p = 0.001$ ,  $\eta_p^2 = 0.597$ ) and Skill Level ( $F(2,27) = 3.961$ ,  $p = 0.031$ ,  $\eta_p^2 = 0.227$ ). Bonferroni corrected pairwise comparisons showed that for Stimulus Type, response accuracy was significantly greater in non-deceptive compared to deceptive trials ( $p = 0.001$ ). For Occlusion Point, response accuracy at +100ms and 0ms was significantly greater than at -100ms ( $p$ 's  $< 0.05$ ), but no difference was found between 0ms and +100ms ( $p > 0.05$ ). For Skill Level, the only difference identified was that experts were significantly more accurate than novices ( $p = 0.046$ ).

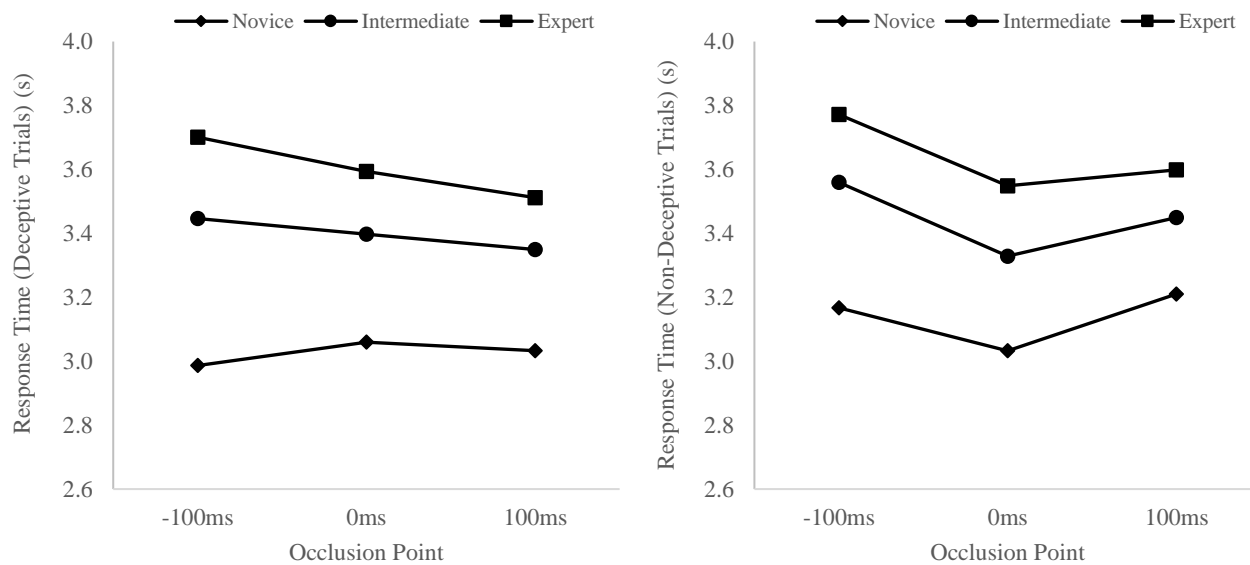
A significant interaction was evident between Stimulus Type and Occlusion Point ( $F(2,54) = 14.693$ ,  $p = 0.001$ ,  $\eta_p^2 = 0.352$ ). Follow-up analysis, using one-way ANOVAs, showed that for Non-Deceptive trials there were no significant differences in Response Accuracy as a function of Occlusion ( $F(2,87) = 2.229$ ,  $p = 0.238$ ). For Deceptive trials, there were significant differences in response accuracy as a function of Occlusion ( $F(2,87) = 22.632$ ,  $p = 0.001$ ). Post hoc tests in the form of Bonferroni corrected pairwise comparisons, showed that Response Accuracy improved significantly between -100ms and 0ms, and -100ms and +100ms; ( $p$ 's  $< .05$ ). No further two-way or three-way interactions were evident ( $p$ 's  $> 0.05$ ).



**Figure 13.** Mean Response Accuracy scores on Deceptive trials (left) and Non-Deceptive trials (right) at each occlusion point

#### *Response Time differences*

The mean Response Times for Deceptive and Non-Deceptive trials are shown in Figure 14. Main effects were evident for Stimulus Type ( $F(1,27) = 12.762, p = 0.001, \eta_p^2 = 0.321$ ), Occlusion Point ( $F(2,54) = 5.898, p = 0.005, \eta_p^2 = 0.179$ ) and Skill Level ( $F(2,27) = 5.301, p = 0.011, \eta_p^2 = 0.282$ ). Bonferroni corrected pairwise comparisons showed that for Stimulus Type, response times were significantly quicker in deceptive, as opposed to non-deceptive, trials ( $p < .05$ ). For Occlusion Point, responses were significantly slower in -100ms trials than 0ms trials ( $p < .05$ ). For Skill Level, experts were significantly slower than novices ( $p < .05$ ). No significant two-way or three-way interactions were found ( $p$ 's  $> 0.05$ ).



**Figure 14.** Mean Response Times on Deceptive trials (left) and Non-Deceptive trials (right) at each occlusion point

#### *Reinvestment and Response Accuracy*

In the first hierarchical regression analysis, Response Accuracy during Deceptive trials (occluded at -100ms) was used as the dependent measure, with skill level controlled for in Step 1. Skill level did not account significantly for Response Accuracy variance ( $p > 0.05$ ). In Step 2, the various reinvestment scores were entered. MSRS (Conscious Motor Processing) significantly predicted 13% of Response Accuracy variance, with higher Conscious Motor Processing scores associated with decreased Response Accuracy ( $\beta = -0.359$ ,  $p = 0.047$ ). No other scores contributed significantly ( $p$ 's  $> .05$ ). The second hierarchical regression, investigating Response Accuracy during Non-Deceptive trials (occluded at -100ms), revealed no effect for any of the reinvestment scores entered ( $p$ 's  $> 0.05$ ).

#### *Reinvestment and Response Time*

Hierarchical regression analyses were used to investigate the effect of reinvestment on Response Time during Deceptive and Non-Deceptive trials (both occluded at -100ms). No significant models were identified ( $p$ 's  $> 0.05$ ).

## Discussion

The current study was designed to improve understanding about anticipation of deceptive and non-deceptive movements, with particular emphasis on skill level differences and propensity for reinvestment. To investigate this, expert, intermediate and novice rugby players anticipated deceptive and non-deceptive changes of direction, viewed through a VR headset. With regards to skill level differences, experts were significantly more accurate than novices during deceptive and non-deceptive trials, consistent with previous research (Cañal-Bruland & Schmidt, 2009; Abernethy et al., 2010; Cañal-Bruland, et al., 2010). The superiority of experts is due to greater experience of perceiving and performing such actions (Cañal-Bruland et al., 2010), which allows them to tune into underlying kinematics that indicate movement outcome, thus, reducing erroneous judgements. Runeson and Frykholm (1983) showed that even when a person attempts to move deceptively, kinematics that indicate movement outcome remain present.

For both deceptive and non-deceptive trials, anticipation accuracy was highest when trials were occluded later. Consequently, experts were more accurate than novices at all occlusion points - even before reliable information was available (-100ms and 0ms). Previous studies have found that the expert advantage persists in picking up information from early kinematics (i.e., before reliable information is presented) that specifies the outcome of an action (Jackson et al., 2006; Aglioti et al., 2008; Abernethy et al., 2008). Experts in the current study were also shown to take significantly longer to respond than novices in both deceptive and non-deceptive trials. This is consistent with Brault et al's (2012), who concluded that waiting longer allowed experts to pick up more information about final running direction. These findings suggest that through experience experts develop a speed-accuracy trade off that allows them to make an accurate judgement before the decision making threshold (the point when a decision must be made – Johnson, 2006).

In the present study, novice, intermediate and expert players were found to make significantly more erroneous judgements on deceptive compared to non-deceptive

side-steps. This differs from Jackson et al's (2006) finding that less skilled participants were more susceptible to deceptive movements. However, experts' response accuracy in the current investigation was a mere 2.25% higher in non-deceptive than deceptive trials - compared to 7.5% and 11.75% for intermediates and novices, respectively. A further finding showed that regardless of skill level, participants took significantly longer to respond during non-deceptive trials. This may show a learning effect. In non-deceptive trials, participants may have waited to see if the player would change direction (as in deceptive trials) or continue in the primary direction (as in non-deceptive trials). The current study used single side-steps for deceptive trials (i.e., step to the left before changing direction to the right) as opposed to double side-steps (i.e., step to the left, step to the right then finally change direction to the left – Mori & Shimada, 2013). Therefore, once participants saw the player change direction in deceptive trials they could be fairly sure that this was the final running direction.

The second line of inquiry in the current study asked whether higher reinvestment scores lead to slower and/or less accurate decisions during deceptive and non-deceptive side-steps. Contrary to our hypothesis, DSRS scores seemed to play no part in speed or accuracy of anticipation in either deceptive or non-deceptive trials. However, this may be due to the low complexity of the task (i.e., the observed player could only run to the left or right). In Kinrade et al's (2015) basketball study, performance decrements were associated with DSRS scores in the high complexity (4 choice) condition, but not the low complexity (2 choice) condition.

Interestingly, MSRS scores were shown to predict poorer accuracy during deceptive trials (occluded at -100ms) when skill level was controlled for. High reinvestors, who are more aware of the opponent's movement patterns may focus too much on the superficial cues that are presented during the deceptive movement (e.g., the initial shift towards the unintended final direction; gaze direction etc) and fail to distinguish the underlying kinematics. This is a novel finding in the literature to date and warrants further consideration to understand the underlying mechanisms.

A limitation of the current study was that verbal rather than movement responses were used to measure response accuracy and time. Participants were encouraged to couple these responses with a physical response; however, a more sophisticated method, similar to Brault et al (2012), may be desirable. Brault et al (2012) attached external markers over body joints to compute the participant's centre of mass, which were compared to the opponent's movements at various time points (e.g., initiation of deceptive signals). Future studies should also implement wider, more realistic types of side-step (i.e., single and double), with a larger sample of participants. With regards to the fidelity of the stimuli, participants rated these as 7.83 out of 10, suggesting that the stimuli were realistic within the VR environment - providing a promising methodology for future studies.

## **Conclusion**

Side-steps are a common deceptive tactic used by attacking players to deceive a defender. Our results suggested that expert rugby players were significantly more accurate than novices when anticipating deceptive and non-deceptive changes of direction. Experts also took significantly longer to respond than novices. To date, the propensity for reinvestment has not been investigated with regards to anticipation of deceptive movements. MSRS (Conscious Motor Processing) scores were associated with poorer response accuracy during deceptive trials. A propensity to consciously process one's movements may disrupt the processes individuals use to understand an opponent's kinematics (by comparing them to their own movement technique).

## Chapter 5

### Experiment 4: Examining deceptive behaviours by attackers in rugby union: The influence of decoy runners on defensive performance<sup>5</sup>

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Chapter 4 focused on deceptive behaviours and asked how consciousness affects anticipation of such movements. Results suggested that, contrary to our hypotheses, decision reinvestment plays no part in anticipation performance. However, propensity for Conscious Motor Processing (a subscale of the Movement Specific Reinvestment Scale) was correlated with poorer anticipation of deceptive changes of direction. A unique form of deception, commonly used in rugby union, was the focus of Chapter 5. The experiment aimed to better understand the use of decoy runners by probing what factors facilitate their efficacy as a deceptive tactic.

#### Abstract

Deceptive tactics are commonly used in sport; however, the psychological mechanisms underpinning the effectiveness of these tactics are unclear. Increasingly in rugby union, decoy runners are used to cause deception. Multiple players in an attacking team run option lines off the ball carrier, making it possible that any of the players could receive the ball. Runners who do not receive the ball are decoys. The aim of the tactic is for the decoys to attract attention from defending players, which creates confusion about which player will receive the ball. The study aimed to identify behaviours of option line runners that can be used to improve the effectiveness of this deceptive tactic. An observational analysis of completed scrums from the 2015 Super Rugby season (n=260), during which decoy runners were used by the attacking side, was completed. Decoy characteristics, including Hands Up, Line Change and Hands Up with Line Change were noted following

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<sup>5</sup> Based on: Sherwood, S., Masters, R. S. W., & Smith, T. B. (2018). Examining deceptive behaviours by attackers in rugby union: The influence of decoy runners on defensive performance. *International Journal of Sports Science & Coaching*, 13(6), 1100-1107.



each scrum. Gainline success was used as a dependent measure of the efficacy of the decoy characteristics. Characteristics were included in a binary logistic regression analysis to develop a best-fit model for gainline success. Results indicated that Hands Up, Line Change, and Hands Up with Line Change significantly improved the likelihood of gainline success seven, eight and six times, respectively. We discuss possible mechanisms that underpin the effectiveness of decoy runners and make recommendations for coaches.

## **Introduction**

Decision-making is a key determinant of successful performance in sport (Royal et al., 2006; McMorris, 2004), so it is not surprising that it has been a topic of much interest in recent decades (Zakay, 1984; Baker, Cote, & Abernethy, 2003; Hohmann, Obelöer, Schlapkohl, & Raab, 2016). Nevertheless, many gaps exist in current understanding of the mechanisms underpinning decision-making, especially in under-researched sports, such as rugby union.

A common approach to researching decision-making has been to identify differences between novices and experts (Abernethy & Russell, 1987; Mann et al., 2007; Rowe, Horswill, Kronvall-Parkinson, Poulter, & McKenna, 2009; Travassos et al., 2013; Lorains et al, 2013a). In a meta-analysis of the research that has examined expert-novice differences, Mann et al (2007) noted that experts have generally been shown to have superior ability to extract information or cues from the environment in order to anticipate future events, and to have enhanced perceptual-cognitive skills, including more efficient allocation of attention.

The use of deception to inhibit the efficiency of an opponent's decision-making is common in sport (see Güldenpenning et al., 2017, for a review); however, the processes that underlie deception are unclear. Jackson et al (2006) defined deception as “providing information that misleads or ‘fools’ an observer into making an incorrect judgment” (p. 356). Deception has been examined in the context of football penalty kicking (Lopes, Jacobs, Travieso, & Araújo, 2014), handball throwing (Alsharji & Wade, 2016), head fakes in basketball (Kunde, Skirde, & Weigelt, 2011; Weigelt, Güldenpenning, Steggemann-Weinrich,

Alaboud, & Kunde, 2017) and sidestepping in rugby (Mori & Shimada, 2013; Jackson et al., 2006), although the focus has almost exclusively been on asking who is more susceptible to deceptive movements and why.

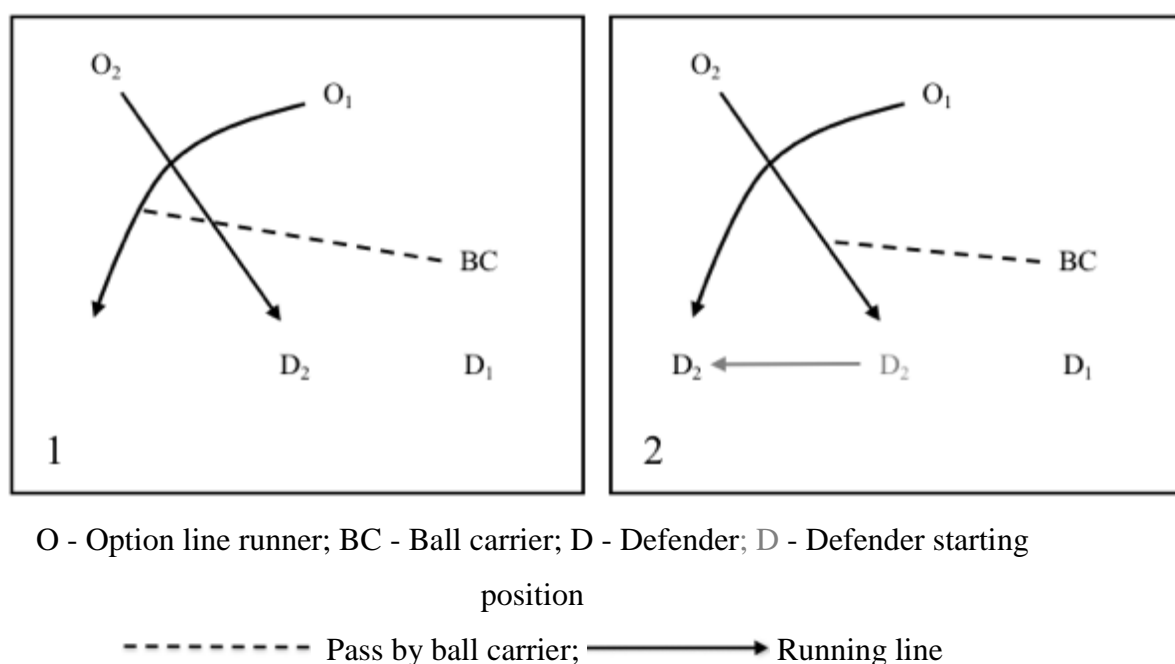
The mechanisms underpinning the effectiveness of deceptive movements are ambiguous. Schmidt and Wrisberg (2008) proposed that deception inhibits effective decision-making because two or more stimuli that require a response are presented in quick succession, which creates a psychological refractory period (PRP). Typically, the PRP results in delayed, often incorrect, responses to the second stimulus because the first stimulus is still being processed. The briefer the interval between the stimuli (the stimulus onset asynchrony), the greater the response time to the second stimulus (Pashler, 1994). Practice does not eliminate this central bottleneck effect (Welford, 1952; Ruthruff, Johnston, Van Selst, Whitsell, & Remington, 2003; Ruthruff, Van Selst, Johnston, & Remington, 2006), but it can reduce the PRP by speeding up processing of the first stimulus (Nakamoto & Mori, 2010).

Previous research in deception (Runeson, Juslin, & Olsson, 2000; Smeeton & Williams, 2012) has investigated what causes an individual to be misled by the movements of an opponent (e.g., how a goalkeeper predicts the direction of a deceptive penalty taker's kick). The current investigation offers a different viewpoint by exploring deception within the dynamic environment of team sports. Specifically, the study examines the influence of actions by attacking players in rugby union who do not receive the ball and are therefore purely moving objects introduced to confuse defenders with respect to which attacker will receive the ball.

A popular tactic used by attacking teams in rugby union is to ask multiple players to run off the ball carrier (player in possession of the ball). This tactic causes more than one player to become a viable option to receive a pass from the ball carrier. These players are sometimes called option line runners. Importantly, the tactic is most successful when the decision about which runner will receive the ball is not predetermined (Hadfield, 2009). That is, by monitoring the dynamic positioning of defensive players, which cannot be predetermined, the ball carrier can choose the runner who is in the best position to cross the gainline. The gainline in rugby union

is an imaginary line parallel to the halfway line, which intersects the back edge of the defending scrum (Biscombe & Drewett, 2010) and is commonly used as a measure of the success of attacking plays. Option line runners who do not receive the ball become ‘decoy runners’. The aim of this tactic is to cause defensive players to be unsure who will receive the ball and, ultimately, to deceive them into inappropriate defensive manoeuvres. Inappropriate defensive manoeuvres include attempting to tackle the decoy rather than the player who actually receives the ball, or getting into a position to do so. Effective decoy runners can confuse and isolate defenders because the play unfolds so quickly that there is little time for defenders to react appropriately (Johnson, 2014).

Figure 15 provides a typical example from rugby union, which illustrates how three offensive players can potentially deceive two defensive players by running different option lines. The task of the ball carrier (BC) is to pass the ball to an option line runner (O) who the defender (D) is least ready or able to defend. Panel 1 shows defender D<sub>2</sub> well positioned to defend the line run by O<sub>2</sub>. Consequently, the optimal decision for BC is to pass behind O<sub>2</sub> to O<sub>1</sub>. Panel 2, on the other hand, shows defender D<sub>2</sub> manoeuvring to defend the running line of O<sub>1</sub>. Consequently, the optimal decision for BC is to pass to O<sub>2</sub>. In the examples below, the runner who does not receive the ball becomes the decoy (i.e., O<sub>2</sub> in Panel 1 and O<sub>1</sub> in Panel 2).



**Figure 15.** Examples of typical decoy runner option lines used in rugby union.

Of particular importance to coaches is to understand how deception can be maximised by decoy runners. For example, the power of the decoy runner tactic to deceive is likely to be greatly enhanced if defending players are convinced that a particular runner is going to receive the pass. Experts, such as Manu Tuilagi, England Centre during the 2011 Rugby World Cup, advocate that it is important to “know that if you are going to run as a decoy, you are still running as if you’ll get the ball” (cited in Hickie & Donaldson, 2015, p.199).

Initial discussions with professional coaches identified key behaviours that decoy runners should display to increase the likelihood of gainline success. The aim of the current investigation was to test the deceptive efficacy of such behaviours. Passages of play arising from real world scrums during professional games were deemed to provide an optimal setting in which to examine this issue. Scrums were used as they tend to be more structured than open play. Additionally, teams often operate pre-planned moves in the passage of play that is initiated by a scrum, during which decoy runners are employed to create confusion among opposing defenders. The behaviours recorded included whether the hands of the runner were up (as if to catch the ball), whether the runner deviated from the original running line (as if to exploit a gap in the defensive line) or whether the runner displayed both behaviours. The success of the attacking play was used as the dependent variable, and was determined by whether the runner who received the ball crossed or did not cross the gainline.

## **Method**

### *Match footage*

Footage was obtained from every game of the Super Rugby 2015 season (N=129), including the finals. Footage was recorded by commercial broadcasting stations. All matches had a minimum of 3 different viewing angles (side-on wide, side-on close, end on). A small proportion of matches had a fourth viewing angle, a combination of the 3 angles, which the public could view through the broadcasting

stations. Sportscade (Version 10, Sportstec, Australia) was used to combine and view the footage, with playback speed controlled frame-by-frame if necessary.

### *Match analysis*

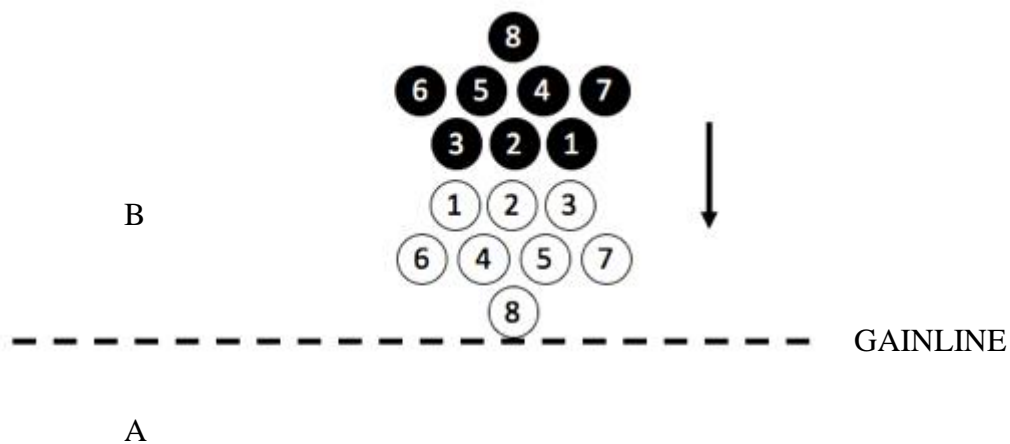
Only passages of play immediately following completed scrums were analysed. Of 970 scrums that took place, 260 were categorised as ‘completed’. A completed scrum was defined as any scrum that was won by the attacking team without causing an infringement (i.e., penalty or free kick). Scrums were only included in the analysis if they were successfully completed (i.e., no reset or penalty against either side). Clips were not analysed if the ball was kicked by one of the attacking players in the first phase of play, if the attacking play had less than one decoy runner or if player error resulted in poor quality ball. Poor quality ball was defined as any event that made it impossible to conduct a successful attacking play, such as a knock-on or the ball exiting the scrum at a peculiar speed or angle.

### *Variables*

Gainline success was adopted as the primary dependent variable in the present study, because it represents the minimal criterion by which an attacking player with the ball in hand can be deemed to have been successful. As is illustrated in Figure 16, the gainline during a scrum is usually immediately behind feet of the defending Number Eight. The black team is attacking in the direction of the arrow and the dashed line represents the black team’s gainline. In the present study, gainline success was achieved if the ball was carried beyond the back edge of the defending scrum by the attacking team’s ball carrier (BC). In Figure 16, for example, this would occur if the BC was tackled at point A. If the BC did not carry the ball to the gainline (e.g., was tackled before reaching the gainline, such as Point B in Figure 16), the play was categorized as unsuccessful.

Line breaks were included as an additional dependent variable to provide information relating to attacking success. A line-break has been defined as “when an attacker in possession of the ball manages to get behind the defense, thereby causing them (defenders) to turn” (Peters & O’Donoghue, 2014, p. 81). To

understand the effect of decoy runners on defenders, common ineffective defensive manoeuvres were recorded from each scrum instance. These manoeuvres included whether a defender changed speed to ensure that they were in an appropriate position to tackle the decoy (Changed Speed), whether a defender planted their feet to tackle the decoy (Planted), whether a defender changed their direction of running towards the decoy (Changed Direction) or whether the defender/s did not change their behavior (No Change). As decoy runners can affect more than one defender, the number of defenders that displayed any of the above characteristics was also recorded.



**Figure 16.** The gainline at a scrum

The primary independent variable considered was the number of decoy runners who appeared in the first phase of play after the scrum (Decoy Runners). Initial assessment, and discussions with world-renowned Super Rugby winning coaches, identified behaviours by decoy runners that were considered as secondary independent variables. Behaviours were only considered in decoy runners (i.e., option line runners who did not receive the ball). The secondary independent variables identified were (1) runner displayed hands clearly as if to catch the ball (Hands Up), (2) runner clearly changed running line (Line Change), (3) both characteristics observed (Hands Up/Line Change). Note that runners could not be included in more than one category. The variables were differentiated by visual observation, so each characteristic had to be pronounced and obvious. Due to the subjective nature of the visual observation method, a second appropriately skilled

independent observer scored a randomly selected proportion of the clips ( $n = 100$ ) in order to establish reliability levels.

The responsibility for which option line runner to pass the ball to lies with the BC, who usually is the scrum-half or fly-half during passages of play immediately following scrums. These positions have been described as the ‘eyes of the team’ (Greenwood, 2003), although occasionally the responsibility may fall to other backs or to the Number Eight (the player at the back of the scrum who has the option to pick up the ball or leave it for the scrum half). The decision of the BC to pass or to run was noted for analysis, as it was of interest to determine whether this moderated the effect of decoy runners on defensive decision-making. The BC was identified and the remaining attacking players were coded by whether their movements interacted with the BC to signal clearly that they were an option to receive the ball (Option) or clearly that they were not an option to receive the ball (Non-option).

#### *Data analysis*

SPSS (Version 24, IBM, UK) was used to conduct the analysis. Chi-Squared tests were used to examine the effect of (1) BC decision (pass or run) on gainline success and (2) number of decoy runners on gainline success. The different characteristics the decoy runners displayed (Hands Up, Line Change, Hands Up/Line Change) were then included in a binary logistic regression analysis in order to develop a best-fit model that described the likelihood of gainline success in the presence of the independent variables. Each independent variable was included as a dichotomous categorical variable (e.g., ‘hands up’ was coded as 1 and ‘hands not up’ was coded as 0). Line-breaks and inappropriate defensive manoeuvres were presented as percentages to provide additional insights into attacking success and its causes. A chi-squared test of independence was used to examine differences in instances of the defensive manoeuvres when the different decoy runner’s characteristics were displayed.

## Reliability

The reliability of the main rater's (i.e., the first author) scoring of the clips was established by computing an intra class correlation (ICC) with the 100 randomly selected clips that were also scored by an independent rater. Satisfactory reliability was demonstrated by 91% agreement rate (ICC= 0.95,  $p < .05$ ).

## Results

Table 2 shows the number of scrums included within each of the analyses undertaken. Table 2 also displays the instances of each decoy runner characteristic, the different ball carrier decisions and attacking outcomes based on gainline success and line break percentage.

**Table 2.** Scrums included within analysis (N), percentage (%), proportion of scrum plays that crossed the gainline (Gainline Success %) and percentage of line breaks (Line break %)

	N	%	Gainline Success (%)	Line break (%)
Total 'completed' scrums	260	100	77.5	27.7
1 decoy runner	210	81	77.6	27.1
2 decoy runners	50	19	77	30
Ball Carrier passed	190	73	80.8	26.3
Ball Carrier ran	70	27	70.9	31.4
Decoy runner hands up	37	14	89.2	35.1
Decoy runner changed running line	36	14	91.7	38.9
Decoy runner hands up and changed running line	26	10	94.2	38.5
Decoy runner did not have hands up or change running line	161	62	68	21.7



Chi-Squared analysis of the effect of number of decoy runners on gainline success showed no significant difference between one and two decoy runners ( $X^2 = 0.079$ ,  $p > 0.05$ ). Similar analysis of the effect of whether the ball was passed or run by the ball carrier also revealed no significant difference ( $X^2 = 0.229$ ,  $p > 0.05$ ). Due to the first finding, the data for plays involving one or two decoy runners were collapsed together. For plays involving two runners, the behaviours of the decoy runner closest to the ball carrier were used in the analysis. The closest runner's characteristics were deemed to be more meaningful as in all instances where two decoy runners were present (N=50) the further decoy runner failed to display any of the characteristics recorded.

### *Binary Logistic Regression*

Three binary logistic regressions were performed to examine the effects of the different behaviours of the decoy runner on gainline success. Predictor variables were Hands Up, Line Change and Hands up/Line Change. All regression models were statistically significant ( $p < 0.05$ ). The specific details of the models are shown below in Table 3.

**Table 3.** Binary logistic regression results

	B	Exp (B)	SE	Wald	Variance Predicted	<i>p</i>	Nagelkerke $R^2$
Hands Up	2.030	7.611	0.451	20.277	67.2%	0.001*	0.163
Line Change	2.174	8.793	0.476	20.816	67.3%	0.001*	0.176
Hands Up/ Line Change	1.788	5.977	0.493	13.127	66.0%	0.001*	0.108

\* Statistically significant ( $p < 0.05$ )

The statistically significant models state that a decoy runner with hands up increased the likelihood of gainline success 7.611 times ( $B = 2.030$ ,  $SE = 0.451$ ,  $p < 0.001$ ). Similarly, a change of line by a decoy runner increased the likelihood of gainline success 8.793 times ( $B = 2.174$ ,  $SE = 0.476$ ,  $p < 0.001$ ). Lastly, when

combined these factors increased the likelihood of gainline success 5.977 times ( $B = 1.788$ ,  $SE = 0.493$ ,  $p < 0.001$ ).

#### *Defensive manoeuvres*

Table 4 shows how many defenders, on average, were affected by the closest decoy runner to the BC, based on the different decoy characteristics. Additionally, Table 4 shows the percentage of scrums during which defenders displayed the aforementioned defensive characteristics. The chi-squared test to examine differences between decoy characteristics and defensive manoeuvres only showed significant differences in No Change instances ( $X^2(3) = 19.5$ ,  $p < 0.05$ ). The Marascuillo procedure, which compares proportions, was used as a post-hoc test with Bonferonni correction. It was shown that No Change instances were significantly lower in Line Change than No Hands Up or Line Change (<sup>a</sup>) and Hands Up/Line Change than No Hands Up or Line Change (<sup>b</sup>) ( $p$ 's  $< 0.05$ ).

**Table 4.** Average number of defenders affected and percentage of scrums during where defenders Changed Speed, Changed Direction, Planted or didn't change their behaviour (No Change)

	Defenders affected	Changed Speed (%)	Changed Direction (%)	Planted (%)	No Change (%)
All scrums	0.87	82 (32%)	56 (22%)	60 (23%)	74 (28%)
Hands Up	0.95	16 (43%)	7 (19%)	9 (24%)	7 (19%)
Line Change	1.03	10 (28%)	12 (33%)	11 (31%)	4 (11%) ( <sup>a</sup> )
Hands Up/Line Change	1.15	10 (38%)	5 (19%)	10 (38%)	2 (8%) ( <sup>b</sup> )
No Hands Up or Line Change	0.76	41 (26%)	26 (16%)	30 (19%)	61 (38%) ( <sup>a</sup> <sup>b</sup> )

## **Discussion**

The aim of the present study was to examine whether the behaviour of decoy runners influences gainline success in rugby union. Decoy runners were assessed in a retrospective analysis of Super Rugby matches during the 2015 season, using the following criteria: hands up, changed running line or both characteristics. The location at which the player who received the ball was tackled (during the first phase of play following a scrum) was compared to the gainline location to ascertain whether the play was successful.

The findings suggest that decoy runners can have a major effect on defences by displaying certain behaviours. When runners in our sample had their hands up, as if to catch the ball, they were seven times more likely to cross the gainline than when their hands were not up. Similarly, changing running line or combining this with hands up increased the chances of crossing the gainline by eight and six times, respectively. Furthermore, a second decoy runner who is further from the ball carrier does not significantly improve the chances of gainline success, promoting a quality over quantity ideology when using deception in rugby union. The results suggest that any decoys over-and-above the nearest (and arguably most viable runner) are surplus to requirements. It is interesting that Hands Up/Line Change did not yield the highest increased likelihood of gainline success in the regression analysis. The effect may be a consequence of Hands Up/Line Change occurring less often than the other behaviours; however, it is also possible that the combination of deceptive behaviours resulted in 'overselling' the decoy, which led experts to see through the deceptive act (Jackson et al., 2006).

Schmidt and Wrisberg (2008) suggested that deception creates a psychological refractory period, which can cause a delayed and/or incorrect decision. Drift defence systems in rugby union are likely to make defenders vulnerable to the refractory period. A drift defence is a system in which defenders line up against an opposing attacker and drift onto the next attacker once the ball has been passed (Thompson, 2011). The fast pace of the game means that defenders must sometimes drift before the ball is passed, especially when the attacking team outnumbers the

defensive team. Defenders must therefore anticipate which attacking player will receive the ball and decide whether to continue to defend against the opposing attacker or drift to the next attacker. Hickie and Donaldson (2015) suggested that decoy runners can inhibit a drift defence by causing a defender to ‘check’ before drifting. ‘Checking’ implies that the defender has been convinced that the decoy runner will receive the ball. However, when the ball is passed its flight path allows the defender to identify who will actually receive the ball. The time between processing, or ‘checking’, the decoy runner causes a refractory period. When the defender eventually attends to the runner who actually receives the ball, it is usually too late to respond effectively because the defender is in an inappropriate position to make a tackle. Reynolds (2002) describes this indecision as ‘decision-making aporia’, during which a momentary irresolvable internal conflict has occurred between drifting and tackling the runner.

The results in Table 4 illustrate an increased proportion of ineffective defensive manoeuvres when decoys displayed characteristics deemed to be critical for attacking success. This provides support for a PRP explanation of our findings, as the ineffective defensive manoeuvres (Changed Speed, Changed Direction and Planted) suggest that defenders had to process the first stimulus (the decoy) before they could process the second stimulus (the attacker who received the ball). Importantly, PRPs usually occur when two or more stimuli, requiring a response, are presented in quick succession (less than 300ms - Welford, 1952). To establish whether a PRP explanation is feasible for the current findings, the stimulus onset asynchrony (SOA) between the first stimulus (hands up and/or line change) and the second stimulus (when the ball was passed) was recorded from a random selection of scrums ( $n = 10$ ). The SOAs are displayed below in Table 5.

**Table 5.** Stimulus onset asynchrony (SOA) timings in Hands Up, Line Change and Hands Up/Line Change instances

	Hands Up	Line Change	Hands Up/Line Change	
			Hands Up	Line Change
N	10	10	10	10
Average SOA (s)	0.148	0.190	0.072	0.234
Standard Deviation	0.125	0.155	0.099	0.177

One explanation for the findings in the current investigation is that some behaviours cause inattentional blindness, during which observers fail to become aware of an unexpected object clearly within their field of vision when their attention is diverted to another object (Mack & Rock, 1998). Many studies have investigated inattentional blindness in real-life events, such as interpretation of scans in radiology (Drew et al., 2013), driving (Pammer & Blinks, 2013) and witness reports of crimes (Chabris et al., 2011). The inattentional blindness paradigm has also been used to explain a variety of phenomena in sport (e.g., Furley et al., 2010; Memmert, 2006; Simons & Jensen, 2009). Memmert and Furley (2007), for example, suggested that inattentional blindness explains why soccer players sometimes claim that they did not pass to a teammate in an obvious scoring position because they did not see them. The effectiveness of decoy runners in rugby union may therefore be a function of attracting (and thus diverting) the attention of the defender, who fails to become aware of the runner who will actually receive the ball, even though that player is within the defender's field of vision. This explanation is speculative, as we are unable to determine from our video clips whether runners who received the ball were in the defender's field of vision or whether their gaze was directed elsewhere. Players may be more likely to experience inattentional blindness in less structured rugby environments, which commonly occur after the first phase of play.

Discussions with coaches suggest that other variables may also have an impact on gainline success. These include whether the runner has eyes on the ball carrier, calls for the ball or changes running speed – all are behaviours that may suggest that the

runner genuinely expects to receive the ball from the ball carrier. These variables could not be differentiated in the game footage used in the current investigation, but warrant consideration in further research. This research might take on a qualitative approach where players and/or coaches are interviewed to gain a greater understanding of deceptive tactics in rugby union. A limitation of the methodology used in the current study is the subjectivity of analysis. Despite the high reliability of the scoring, a more strictly controlled analysis is desirable in future studies. For example, looking at the success of the same pre-planned move, performed a number of times with varying characteristics shown by decoy runners.

The findings provide coaches with useful information on how to best train decoy runners. In coaching literature, professional coaches claim that decoy runners should run with 'real purpose' (e.g., Hickie & Donaldson, 2015). This suggests that the behaviour of such runners is an important consideration for coaches. However, runners in our study failed to display behaviours deemed critical to gainline success on 62% of occasions. Our research highlights the importance of runners behaving like they expect to receive the ball and provides some easy, trainable techniques that coaches can use. An important consideration for coaches is that runners will not be certain if they will receive the ball until the BC makes a decision. Therefore, as mentioned previously, coaches should promote the idea that all runners should adopt the critical behavioural characteristics to maximise deception. Future work might consider the effect of asking the runner who receives the ball to behave as if not expecting to receive the ball. For example, keeping the hands down until the last possible moment before receiving the ball may capture minimal attention from defenders, with devastating consequences.

## **Conclusion**

Employing multiple decoy runners is a common deceptive tactic implemented by attacking teams in rugby union to breach defenses and cross the gainline. This form of deception, created by players who are not in possession of the ball, is unique in the deception literature to date. The present study aimed to understand what effect different behaviours by decoy runners has on gainline success. The results suggest that runners are more effective if they act like they will receive the ball by holding

their hands up and/or deviating from their original running line. Suggestions have been made for why these results were observed; however, future research needs to uncover the true mechanisms underpinning the effectiveness of decoy runners.

## Chapter 6

### Experiment 5: Inattentional blindness in Rugby Union: A clean break<sup>6</sup>

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Chapter 5 investigated the effect of decoy runner behaviours on defensive performance. It was shown that this deceptive tactic is more successful if decoys display behaviours that imply they will receive the ball. It was suggested that these behaviours (Hands Up or Line Change) divert the defender's attention, which causes them to be inattentionally blind to the attacker who receives the ball. In Chapter 6, we attempted to provide evidence to show inattentional blindness is a plausible explanation for the results observed.

#### **Abstract**

Inattentional blindness occurs when a critical object within the visual array is not noticed if attention is diverted to another task. We investigated whether inattentional blindness is responsible for instances in rugby union in which an attacking player receives the ball and appears to run through a gap in the defensive line - seemingly without being perceived. To examine this question, novice (N = 68) and expert (N = 47) rugby players watched videos that recreated successful attacking plays from real rugby games. Each video was occluded 100ms before the ball was caught by the attacking player who, in the real game, eventually ran through the gap. Participants viewed the plays from a defender's perspective and were required to indicate the exact position of the players in each play when occlusion occurred. During each trial, participants concurrently completed a rugby relevant low-demanding attention task or high-demanding attention task, or no task (control). Results suggested that participants were significantly less likely to notice the player who received the ball in low-demanding and high-demanding conditions

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<sup>6</sup> Based on: Sherwood, S. M., Smith, T. B., & Masters, R. S. W. (under review). Inattentional blindness in Rugby Union: A clean break. *Psychology of Sport and Exercise*



than the control condition. These findings suggest that in certain circumstances inattention blindness may occur in rugby union if attention is diverted to another task in the game.

## **Introduction**

In rugby union, there are occasions when an attacking player breaches the defensive line with ease, almost as if unseen by the defenders. The theory of inattention blindness (IB) suggests that an unexpected object clearly within the field of vision of an observer is sometimes unseen if attention is diverted to another task (Mack & Rock, 1998; Simons, 2007). Simons and Chabris (1999) demonstrated this phenomenon in a well-known study in which participants watched a video of two groups of people wearing different coloured bibs. Each group of players was passing a basketball among themselves while moving around on the court. Participants were instructed to count the number of passes made by one of the groups. During this, an individual wearing a gorilla costume walked amongst the players. Remarkably, half of the participants did not report seeing the gorilla. Simons and Chabris (1999) proposed that participants were inattentionally blind to the unexpected object (i.e., the gorilla) as their attention was diverted to another object/task (counting passes). Further studies have investigated IB in real-life events, including radiologists interpreting scans (Potchen, 2006; Drew, Vö, & Wolfe, 2013), people driving (Strayer, Drews, & Johnson, 2003; Pammer & Blink, 2013), witnesses reporting crimes (Chabris, Weinberger, Fontaine, & Simons 2011) and police officers noticing a dangerous weapon during a vehicle stop (Simons & Schlosser, 2017).

IB has also been used to explain instances in sport during which players fail to notice important events in the environment. Memmert and Furley (2007), for example, asked why players sometimes report retrospectively that they did not see a teammate in a prominent position, despite the teammate featuring in their field of vision. Memmert and Furley (2007) found that 55% of handball players failed to notice an unmarked teammate in a good scoring position when their attention was diverted to the positioning of a defender. Importantly, when attention was not diverted, all players identified the unmarked teammate. An unmarked teammate

cannot necessarily be described as an ‘unexpected object’. However, in their study the unmarked teammate was classified as unexpected due to the unusual position that they assumed (right-wing player completely free in the centre of the field). Other studies in handball (Memmert, 2011) and basketball (Furley, Memmert, & Heller, 2010; Memmert, 2006), have entrenched the claim that IB occurs in sport.

Research into IB suggests that certain characteristics of the (unexpected) object typically affect the chances of it being unseen. These characteristics include colour (Green, 2004; Koivisto, Hyönä, & Revonsuo, 2004), luminance (Most, Scholl, Clifford, & Simons, 2005), shape (Most et al, 2005), size (Mack & Rock, 1998), exposure time (Kreitz, Furley, & Memmert, 2016), animacy (Calvillo & Jackson, 2014), distance from the attentional focus (Newby & Rock, 1998) and similarity to attended items (Most, Simons, Scholl, Jimenez, Clifford, & Chabris, 2001). Another important factor that contributes to the likelihood that IB will occur is the attention demands of the attentionally diverting task. Most et al. (2005) and Simons and Chabris (1999) found that the (unexpected) object was more likely to be noticed if the attentionally diverting task did not require much attention, presumably leaving adequate attention resources available to devote to the rest of the environment.

In high-velocity multi-player sports like rugby union, the complexity of on-field movement is often attentionally diverting, but modern tactics have added to the demands on attention resources. For instance, the use of decoy runners is an offensive tactic that aims to present conflicting information to opposition players about who will receive the ball (Johnson, 2014). The tactic involves multiple attacking players, who are all viable options to receive the ball from the ball carrier (i.e., a pass) - any of these players could receive the ball. This tactic is often implemented in the first phase of play after a scrum; plays are typically predetermined and runners who do not receive the ball are decoys (Sherwood, Smith, & Masters, 2018). The predetermined nature of the plays allows teams to cause certain attacking options (and thus players) to be ‘unexpected’ by the opposition players (e.g., through uncommon positionings or running lines). Sherwood et al (2018) found that the efficacy of decoy runners was improved significantly if they displayed key behaviours that indicated they would receive the

ball; thus, diverting the defenders attention away from the player who actually received the ball. Decoy runners who held their hands up as if to catch the ball or changed their running line as if to exploit a gap in the defensive line, or both, increased the likelihood that the attacking play would be successful by seven, eight and six times, respectively, compared to when the behaviours were not displayed. These behaviours may, therefore, cause attention capture, during which a stimulus draws a person's attention without that person's volition (Folk & Gibson, 2001). Sherwood et al (2018) argued that this may have been the case in their study, speculating that the dramatically increased success of attacking plays in which decoy runners are used may be a consequence of IB. That is, defenders fail to notice the player who receives the ball, because their attention is diverted to players who have their hands up or change their running line, or both.

The present study was designed to test this possibility. A video-based sport inattentional blindness task (SIBT, cf. Memmert & Furley, 2007) was developed using stimuli consisting of plays involving decoy runners, which were recreated from real games and filmed from a defender's perspective. It was hypothesized that participants would be less likely to notice the player who eventually made the clean line break (the film clips were occluded before he received the ball) if their attention was diverted by an attention diverting task that would typically occur when defending during a game of rugby (e.g., counting players with their hands up as if to receive the ball). Such a finding would provide support for our contention that IB can explain relatively rare instances of 'clean' line breaks in the game of rugby union. To date, the role of demand in attention diverting tasks in IB has been overlooked, with the exception of Simons and Jensen (2009), so we varied the demands of the attention diverting task by asking some participants not only to count the number of players with their hands up but also to identify the player who was most likely to receive the ball. Research into expertise effects on IB in sport has not been conducted to date, so by including professional rugby players as well as novices, we also hoped to gain insight into the role of sporting expertise/experience in susceptibility to IB. We hypothesised that professional players would be less susceptible to IB than novices, because more of the novice's attention may be required to complete the attention diverting task. It is assumed that

experts will require less attention for the diverting tasks due to their greater experience of such stimuli (Simon & Chabris, 1999).

## **Method**

### *Participants*

A novice group of participants ( $N = 68$ ) was recruited from university students (aged  $19.53 \pm 2.9$  years) with two years of rugby playing experience at a recreational level or less. An expert group of participants ( $N = 47$ ) was recruited from professional rugby players (aged  $23.66 \pm 2.74$  years) with an average of  $17.16 \pm 3.01$  years playing experience. G\*Power 3.1 analysis (between-subjects ANOVA) suggested that for a medium-to-large effect of  $f = .33$  (based on Memmert & Furley, 2007, Experiment 2) with conventional  $\alpha = .05$  and power = 0.8, we required a sample size of  $N = 76$ . All participants provided informed consent.

### *Test stimuli*

To identify ‘plays’ during which IB may have occurred, ‘clean’ line breaks in the first phase of play following scrums from the Super Rugby 2017 season were examined. A ‘clean’ line break was operationalized as: the player in possession of the ball moving through the defensive line (a straight line between two defenders, or between a defender and the touchline) without being physically contacted by an opposition player (den Hollander, Brown, Lambert, Treu, & Hendricks, 2016). Plays were only used if they included at least one decoy runner (an attacking player who was a viable option for the ball carrier to pass to but did not receive the ball; Sherwood et al, 2018). A final bank of plays ( $N=7$ ) was identified and documented for recreation by noting the starting position of the player involved in each play, their running line and end position, and the movement of the ball (see Figure 17).



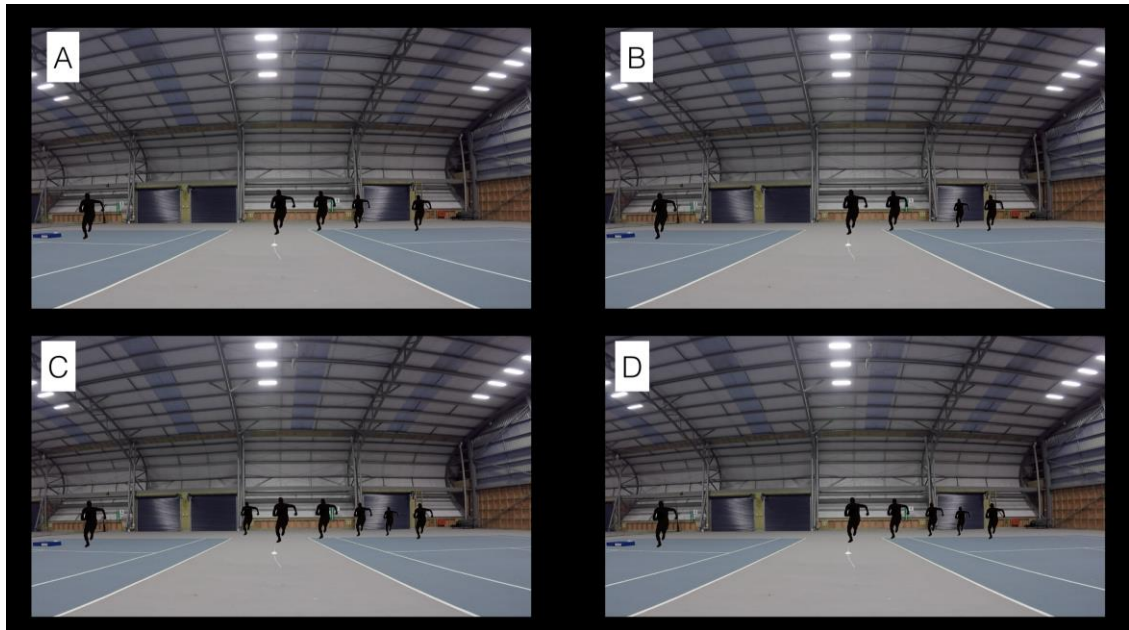
therefore more attention demanding. The duration of each play was an average of 2.3s. The SIBT was made up of one practice trial and six test stimuli. Figure 18 shows the final frame before occlusion from one of the plays.



**Figure 18.** An example of the final frame before occlusion

### *Recognition stimuli*

After viewing each stimulus, participants were asked to recall where performers in the plays were located at the moment that the stimulus was occluded, by selecting one of four different arrays of players. Each array was created using identically posed silhouettes positioned in the exact location that the player occupied immediately before the video occluded. The arrays displayed (1) the correct array (Figure 19, Panel D), (2) the correct array minus the actual ball receiver (Figure 19, Panel A), (3) the correct array minus a potential ball receiver (Figure 19, Panel B) and (4) the correct array plus an extra player uninvolved in the play (Figure 19, Panel C). The panels were randomly ordered for each trial.



**Figure 19.** Example of recognition stimuli

### *Test Procedure*

Each play ( $n=6$ ) was displayed to participants who were seated 3m from the projected image. Immediately after the play occluded, the pattern recognition stimuli appeared (as in Figure 19), and participants were required to respond by indicating the panel that represented the correct array of players immediately prior to occlusion. A between-subjects design was adopted, with participants randomly allocated to one of three conditions. The majority of IB studies have utilized a within-subjects design, but we felt that a within-subjects design would cause unnecessary repetition of the stimuli, causing them to be overly familiar, especially for experts. Simon and Chabris (1999) also used a between-subjects design when examining how different attention demands impact IB. Participants allocated to the Control condition (Con) were required to do nothing else. In an Attention Diverting Low-demand task (Low-demand), participants were required to also count (and report) the number of decoy runners with their hands up during the play. In an Attention Diverting High-demand task (High-demand) participants were required to count (and report) the number of decoy runners with their hands up during the play and also anticipate which player they believed would receive the ball (see Figure 20). A simple breakdown of the task requirements is shown in Table 6.

**Table 6.** Summary of condition requirements

	Primary Task	Attention Diverting Task(s)
<b>Control</b>	Player positions at occlusion	
<b>Low-demand</b>	Player positions at occlusion	Count number of decoys with hands up
<b>High-demand</b>	Player positions at occlusion	Count number of decoys with hands up / identify ball receiver



**Figure 20.** Example of stimuli used to indicate which player received the ball

### *Data Analysis*

For each participant, percentage response accuracy (N=6 different plays) was determined. First, we determined Overall Recall Accuracy (i.e., the percentage of occasions on which the array selected represented the exact position of all players at the moment of occlusion). Second, we examined the types of errors that occurred when recall was incorrect. We did this by determining the percentage of occasions on which participants selected (1) the correct array minus the actual ball receiver (Figure 19, Panel A), (2) the correct array minus a potential ball receiver (Figure



19, Panel B) and (3) the correct array plus an extra player uninvolved in the play (Figure 19, Panel C). The criterion measure in the current investigation was trials in which participants selected the array that did not display the player who actually received the ball. These instances represent occasions when the IB phenomenon is most likely to occur—that is, when an attacking player about to receive the ball appears to be unseen by a defender(s).

SPSS (Version 24, IBM, UK) was used to conduct the analyses. Separate 2 (Expertise: Novice vs Expert) x 3 (Condition: Control, Low-demand, High-demand) between subjects ANOVAs were conducted to first examine differences in overall recall accuracy and then recall errors. Appropriate pairwise comparisons were completed where necessary.

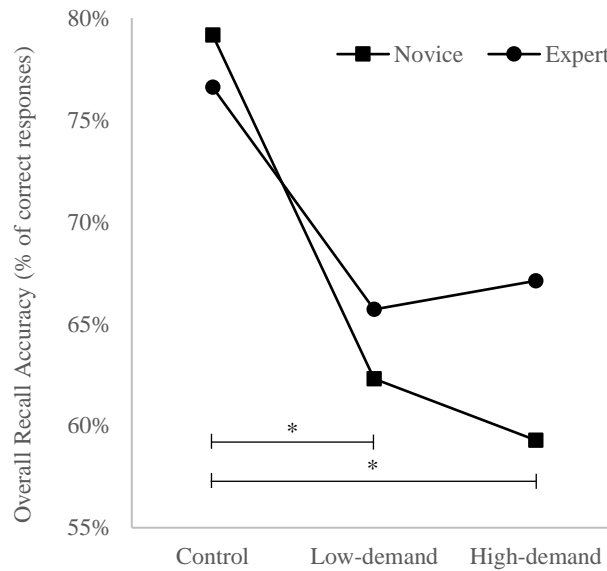
In IB studies, performance of the attention-diverting task is typically recorded to check that participants have given sufficient effort to it (i.e., did not focus mainly on the primary task, at the expense of performance of the attention-diverting task). Consequently, for the attention diverting Low-demand task the number of decoy runners reported with their hands up was recorded and for the attention diverting High-demand task the number of decoy runners reported with their hands up, and who would receive the ball, was also recorded. To test whether performing these attention diverting tasks had an influence on Correct responses or the number of times when the Critical player was unobserved, Pearson correlation coefficients were computed.

## **Results**

### *Overall Recall Accuracy*

For the percentage of occasions on which participants selected the correct array (Figure 21), neither a main effect of Expertise ( $F(1, 94) = .156, p = .694$ , partial  $\eta^2 = .002$ ) nor an interaction between Expertise and Condition ( $F(2, 94) = 1.216, p = .301$ , partial  $\eta^2 = .025$ ) was evident. However, a significant main effect was evident for Condition ( $F(2, 94) = 4.554, p = .013$ , partial  $\eta^2 = .088$ ). Pairwise comparisons showed that overall recall accuracy was greater for the Control condition compared

to the Low-demand and High-demand conditions ( $p$ 's = .042 and .027 respectively). Accuracy did not differ between the Low-demand and High-demand conditions ( $p = 1.000$ ).



**Figure 21.** Overall recall accuracy in the Control, Low-demand and High-demand conditions, as a function of the percentage of correct responses (\* significant difference  $p < 0.05$ )

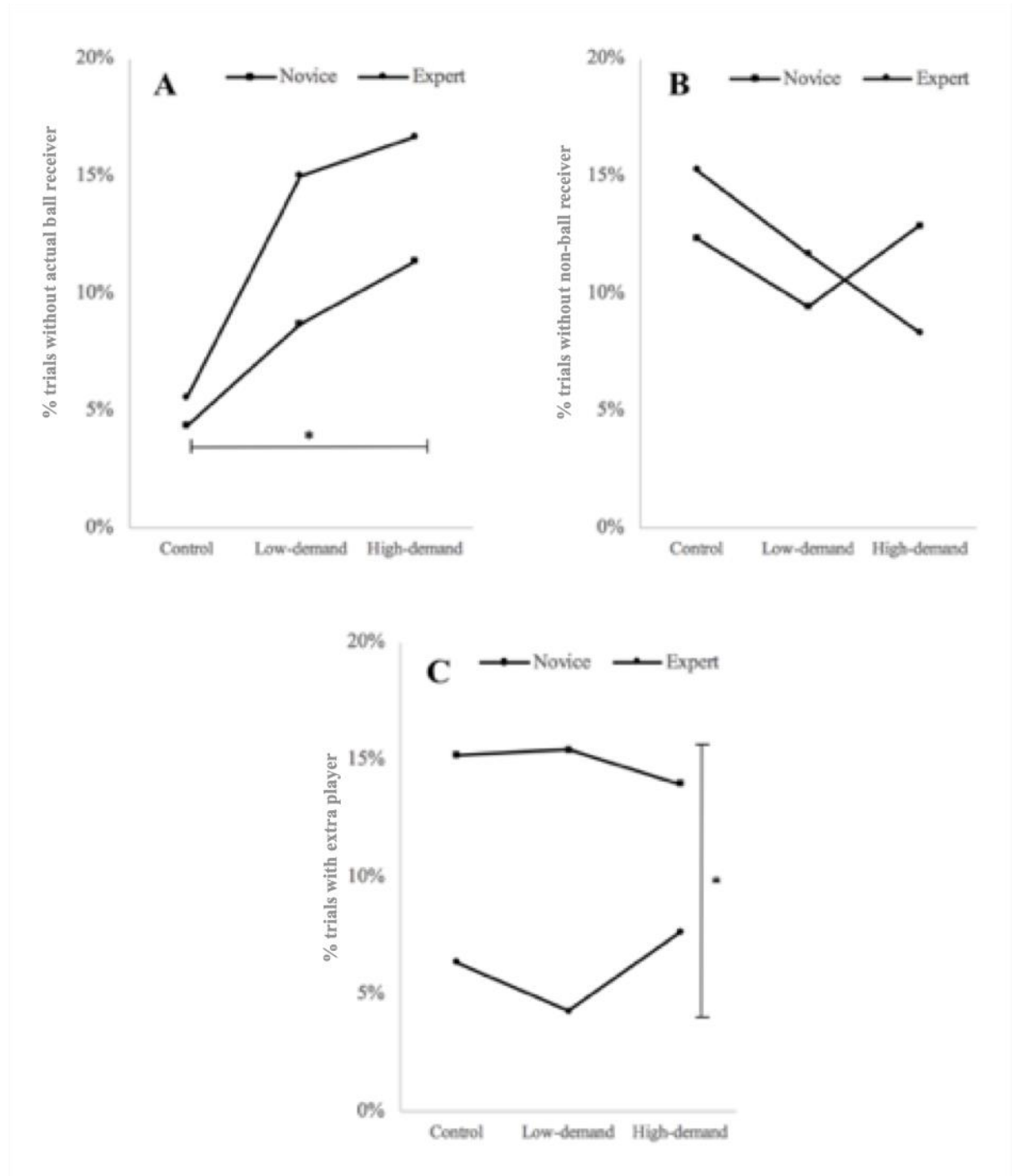
### *Recall Errors*

The main measure of IB was the percentage of occasions on which participants selected an array without the actual ball receiver (Figure 22, Panel A). Analysis failed to reveal a main effect of Expertise ( $F(1, 94) = 2.362, p = .128$ , partial  $\eta^2 = .025$ ). Furthermore, an interaction between Expertise and Condition ( $F(2, 94) = .327, p = .722$ , partial  $\eta^2 = .007$ ) was not evident. A significant main effect was revealed for Condition ( $F(2, 94) = 4.017, p = .021$ , partial  $\eta^2 = .079$ ), with pairwise comparisons showing that the array without the actual ball receiver was selected significantly more often in the High-demand condition than the Control condition ( $p = .025$ ).

For the percentage of occasions on which participants selected an array without a potential ball receiver (Figure 22, Panel B), significant main effects were not found

for Expertise ( $F(1, 94) = .005, p = .945, \text{partial } \eta^2 = .001$ ) or Condition ( $F(2, 94) = .481, p = .620, \text{partial } \eta^2 = .010$ ). An interaction was not evident ( $F(2, 94) = .561, p = .561, \text{partial } \eta^2 = .012$ ).

For the percentage of occasions on which participants selected an array with an extra player (Figure 22, Panel C), a significant main effect of Expertise was evident ( $F(1, 94) = 8.470, p = .005, \text{partial } \eta^2 = .083$ ), with experts less likely to select the array than novices ( $p = .005$ ). Neither a main effect of Condition ( $F(2, 94) = .042, p = .959, \text{partial } \eta^2 = .001$ ) nor an interaction ( $F(2, 94) = .202, p = .817, \text{partial } \eta^2 = .004$ ) was evident.



**Figure 22.** Recall errors in the Control, Low-demand and High-demand conditions, as a function of percentage of occasions on which an array was selected without the actual ball receiver (Panel A), without a possible ball receiver (Panel B) and with an extra player (Panel C) (\* significant difference  $p < 0.05$ )

### *Performance of the attention diverting tasks*

To ensure that participants dedicated sufficient attention to performing each attention diverting task, we computed percentage counting accuracy (i.e., number of players with their hands up) in the Low-demand condition (51.2%) and the High-demand condition (54.17%). For participants in the High-demand condition, percentage of correct responses with respect to which player would receive the ball was 36.25%. Performance of the attention diverting tasks did not differ between experts and novices ( $p$ 's > 0.05) and no correlations were evident between performance of these tasks and overall recall accuracy or recall errors ( $p$ 's > .05).

### **Discussion**

The aim of the present study was to understand whether IB is a plausible explanation for the effectiveness of decoy runners, when they display behaviours that seem to capture attention. It was found that the player who received the ball was not noticed up to 17% of the time when attention was maintained by attention diverting tasks, suggesting that IB may have occurred. Both expert and novice rugby participants were significantly less likely to identify the correct array of players in plays recreated from real games if there was an additional task to be completed at the same time. Furthermore, participants were significantly more likely to recall an array without the actual ball receiver when they were required to count the number of decoy runners with their hands up (a critical determinant of decoy runner efficacy – Sherwood et al., 2018) and determine which player would receive the ball (considered essential for defensive success). This result, specifically, suggests that IB may have occurred, because the player who was to receive the ball was noticed less often when attention was diverted to the secondary tasks. This finding is consistent with work by Memmert and Furley (2007) in which a handball player (in this case a teammate in a scoring position) was often unseen when participants were required to monitor the whereabouts of an opposition player. Our findings, along with those of Memmert (2006; 2011) and Furley, Memmert, and Heller (2010), cement the claim that IB occurs in sport.

Experts were significantly less likely than novices to select an array with an extra player (see Figure 22, Panel C), suggesting that perhaps they had a better understanding of the number of players that might be expected in the plays involving decoy runners. Furthermore, when an extra player was present in the array they were located in a position that was typical of a real game situation. Consequently, for experts the extra player was not located in an unexpected position (unlike the actual ball receiver) and the array could therefore be ruled out more easily. No other statistical differences were evident between experts and novices. To some extent, this is counterintuitive with respect to noticing the actual ball receiver; however, Memmert, Simons, and Grimme (2009) suggested that an expert advantage is likely to occur if the attention diverting task is less demanding. As expert and novice performance of the attention diverting tasks in the current study did not differ, this could explain why no significant difference was evident in rates of noticing the actual ball receiver. Simons (2010), who found similar results to those in those outlined in this paper, argued that foreknowledge that unexpected objects will be present does not facilitate noticing other such objects. For example, knowing that a gorilla will walk through the middle of a video does not improve the chances of noticing a woman with an umbrella. Therefore, although the expert participants may have expected confusion in the plays it did not aid recognition of players. It is noticeable that in both the Low-demand and High-demand conditions there was a trend (non-statistical, we acknowledge) for experts to be more likely than novices to select arrays in which the actual ball receiver was absent (see Figure 22, Panel A). We find this possibility thought-provoking and further research should investigate whether experts are more vulnerable to IB in sport.

An important distinction raised by Memmert (2010) is the difference between IB and attentional misdirection. Attentional misdirection refers to a deliberate diversion of attention away from a stimulus (Memmert, 2010); however, IB occurs when an obvious visual stimulus is not noticed because an individual's attention has not been focused on it (usually as attention is concurrently engaged in another task or tasks). In our study, the attention diverting task(s) focused on all of the possible ball receivers, so attention was not deliberately diverted (misdirected) away from the player who received the ball. Importantly, the main effect of condition was evident only for the percentage of occasions on which participants

selected an array without the actual ball receiver, not for the percentage of occasions on which participants selected an array without a potential ball receiver or for the percentage of occasions on which participants selected an array with an extra player. This is crucial to the claim that IB may have occurred – if participants were simply distracted or misdirected by the secondary tasks it would be expected that all types of recall errors would always be significantly more likely in the High-demand condition.

Previous work has suggested that a more demanding attention diverting task(s) increases the likelihood that IB will occur (Most et al., 2005; Simons & Chabris, 1999). However, for the Low-demand and High-demand conditions in our study, no significant differences were apparent in the percentage of occasions on which participants selected an array without the actual ball receiver. Although participants in the High-demand condition were required to indicate the player who would receive the ball and count how many players had their hands up, their counting was similarly accurate to participants in the Low-demand condition, who were only required to count how many players had their hands up (54.17% and 51.2% respectively). It is probable, therefore, that the additional task of identifying the player who would receive the ball added little in terms of attention demands. The low accuracy that we report for counting ‘hands up’ may indicate that the IB effect was not a function of observers conscientiously counting the players with their hands up, but rather of general monitoring/awareness that some players had their hands up. From an applied perspective, it is useful for an attacking team to be aware of this. It is seldom, if ever, possible to provide opposing defenders with specific instructions about how to defend (e.g., “you need to count how many of our decoy runners have their hands up”), but it appears that merely by raising the hands decoy runners can divert the attention of players in order to increase the chances of an IB effect. It was also shown that better performance on the attention diverting tasks was not associated with recall accuracy. This was also shown by Simon and Jensen (2009) who found that “individual differences in primary task performance did not predict noticing of an unexpected object” (p. 398).

A further potential criticism is that the percentage of occasions on which participants selected an array without the actual ball receiver was relatively low in

the High-demand condition (11% for novices, 17% for experts). However, Memmert (2010) suggested that more attention is paid to the unexpected object if it has a function in the task at hand. Therefore, as identifying the player who would receive the ball was a requirement in the High-demand condition, a smaller rate of IB is to be expected. Although we feel that IB is a plausible explanation for the observed results, clearly there are alternative explanations – mainly associated with errors caused by the visual system, as opposed to attentional errors. As mentioned, a within-subjects design has typically been utilized in previous IB studies. The designs usually conclude with a full-attention trial, where participants have no attention diverting tasks to complete. If participants notice the unexpected stimulus in the full-attention trial (e.g., the gorilla in Simon and Chabris' (1999) study), then visual errors in previous trials that included attention-diverting tasks can be ruled out. Future research might seek to include full-attention trials to rule out any failures of awareness caused by visual errors.

## **Conclusion**

The present study was designed to test whether IB is a plausible explanation for unusual defensive errors in the sport of rugby. Previous research has shown that decoy runners are more effective if they display characteristics that seem to divert attention (e.g., holding their hands up as if they are receiving the ball) so we recreated plays in which this was the case. Our results suggest that asking participants to count the number of decoy runners with their hands up and identify the player most likely to receive the ball caused novices and experts alike to be more likely to commit recall errors in which the player who actually received the ball was unseen. We deem this to be an indicator that inattentional blindness may explain why in rugby union there are occasions when an attacking player breaches the defensive line with ease, almost as if unseen by the defenders.



## Chapter 7

### General Discussion

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The aim of this final chapter is to summarise the key findings from the research conducted and to discuss them with regard to relevant research in the decision making field. Additionally, practical applications for coaches are provided and future directions for research are considered.

#### **Summary of key findings**

The aim of Chapter 2 was to understand whether performance on pattern recall tasks predicts on field decision making performance and, therefore, whether pattern recall tasks can be used as a talent identification tool. The results of the first study showed that professional players with more years of rugby experience were more accurate when recalling structured patterns. However, the tasks did not predict on-field decision making performance (measured using coaches' perceptions of players' decision making ability). In the second study in Chapter 2, expert and novice participants recalled structured, semi-structured and unstructured patterns. Experts were found to be significantly more accurate than novices on structured and semi-structured patterns but there were no significant differences between recall accuracy of unstructured patterns. The conclusion of this second study was that the combination of structured and semi-structured patterns may be more representative of the patterns experienced in a real-life rugby match.

Chapter 3 again centered on pattern recall ability; however, in this instance the effect of decision reinvestment was investigated. The main finding was that individuals with a high propensity to consciously monitor their decision making processes (measured using the DSRS) were slower and less accurate in the pattern recall task. A follow up study suggested that Decay Theory (Brown, 1958) may explain why slower recall lead to poorer accuracy.

In Chapter 4, a novel investigation focused on the effect of reinvestment and expertise on anticipation of deceptive and non-deceptive movements. The results showed experts to be significantly more accurate than novices at anticipating both deceptive and non-deceptive movements. Experts were also shown to take significantly longer to respond than novices. Contrary to our hypothesis, decision reinvestment did not play a role in anticipatory performance; however, increased movement reinvestment tendencies were correlated to poorer anticipatory accuracy of deceptive movements.

Chapters 5 and 6 attempted to understand more about decoy runners, which provided a unique form of deception to investigate. Findings suggested that decoy runners were more effective when they displayed certain characteristics to attract defenders' attention (i.e., hands up as if receiving the ball and line change as if exploiting a gap in the defensive line). Chapter 6 investigated the claim that the effectiveness of decoy runners is greatest when the attention of the defending player(s) is diverted to the decoys, creating momentary inattentional blindness for the player who actually receives the ball. This study showed that the player who received the ball was more likely to be unseen when attention was diverted by a secondary task – suggesting that inattentional blindness may have occurred.

### *Expertise differences*

Expertise was used as an independent variable in Chapters 2, 4 and 6. In Chapter 2, rugby experts were found to recall structured and semi-structured rugby patterns more accurately than novices. In Chapter 4, again, rugby experts showed superior decision making – in this case, more accurate anticipation of deceptive changes of direction. In Chapter 6, however, expertise seemed to have little effect on the key dependent variables used to investigate inattentional blindness. The only expertise difference uncovered was novices' increased likelihood of believing an extra player was involved in the rugby plays.

Mann et al's (2007) meta-analysis of perceptual-cognitive expertise in sport is one of the most highly regarded articles in the field, with over 800 citations. A key

finding of the analysis was that experts respond quicker and more accurately than non-experts. Our results, on the whole, also show that experts respond more accurately than novices. However, the findings from Chapter 4 showed experts to take significantly longer to respond to an opponent's change of direction than novices. Mann and colleagues did state that strategic sports (such as rugby), compared to interceptive sports (such as tennis), consist of 'a more elaborate sequencing of events, which may reduce the impending temporal pressures necessary to perform at a superior level' (p. 473). This may allow expert rugby players to develop a speed-accuracy balance, whereby accuracy is maximised within the temporal constraints of the sport (of which novice players are unfamiliar).

Chapters 2 and 4 investigated different elements of decision making (pattern recall and anticipation, respectively). Importantly, sporting experience was positively associated with different perceptual-cognitive abilities that matched the demands of the task. For example, in Chapter 2, experts were found to be more accurate when recalling structured and semi-structured rugby patterns, but recall accuracy was similar to that of novices on unstructured patterns. The explanation for the observed result was that expertise allows individuals to develop a wide repertoire of chunks and templates to aid encoding and retrieval of the structured and semi-structured patterns, which are experienced multiple times, while avoiding the usual restrictions of short-term memory. In Chapter 4, however, chunks or templates of players' positions within patterns are unlikely to facilitate accurate anticipation based on an opponent's kinematics (e.g., deceptive and non-deceptive changes of direction) due to differences in the task requirements. Rather, it was argued that improved anticipation accuracy of expert performers was a result of motor and perceptual experience of the movement being observed. Motor experience of the movement allows the individual to anticipate the observed player's intent by comparing the kinematics viewed to their own technique when performing the same action. A more detailed understanding of the movement's technique allows for comparisons of intricate and outcome dependent components, resulting in a more accurate judgement. Perceptual experience, however, allows performers to develop an efficient search strategy and attune to the most information rich areas that dictate the outcome of the movement. For instance, in Savelsbergh et al's (2002) study,

investigating goalkeepers' anticipation of penalty kicks, it was ascertained that expert goalkeepers directed their attention to the areas that predicted shot outcome (kicking leg, non-kicking leg and ball areas). Novices, on the other hand, directed their attention to areas that were less informative about the shot's outcome (trunk, arms and hips). Savelsbergh and colleagues, corroborated by Mann et al's (2007) meta-analysis, also found that the search strategies of expert performers involved fewer fixations on cues, but for a longer duration, which allowed them to pick up more information relating to the outcome of the movement.

Expert-novice differences in the quiet eye phenomenon (Vickers, 1996) were also identified by Mann et al (2007). Although this factor is not investigated in the current thesis, it aids understanding of the importance of expertise. Quiet eye relates to the final fixation or tracking gaze that is located on a specific location or object (within 3° of visual angle, for a minimum of 100ms). Higher levels of sport performance - associated with quiet eye – have been shown in golf (Vickers, 1992; Vickers, 2004), basketball (Oudejans, Koedijker, Bleijendaal, & Bakker, 2005), table tennis (Williams, Vickers, & Rodrigues, 2002) and ice hockey (Panchuk, Vickers, & Hopkins, 2017; Martell & Vickers, 2004). Martell and Vickers (2004) ascertained that successful defensive tactics were categorised by fixations of short durations at the beginning of ice hockey plays before concluding with a final gaze of a long duration at a relatively stable target (quiet eye). As with tactical decisions, quiet eye gaze behaviours have also been shown to facilitate accurate anticipatory judgements. For example, Panchuk et al (2017) showed that an early, sustained quiet eye duration predicted a higher percentage of saves made by ice hockey goalkeepers.

### *The role of reinvestment in decision making*

Chapter 3 and Chapter 4 investigated the role of reinvestment in decision making, specifically, pattern recall and anticipation ability, respectively. With regards to pattern recall, high DSRS scores were associated with slower, less accurate recall. Decision reinvestment scores, however, did not seem to influence anticipation performance for either deceptive or non-deceptive changes of direction.

Interestingly, high MSRS scores did have a detrimental effect on anticipation of deceptive changes of direction.

The deleterious relationship found between decision specific reinvestment and pattern recall ability is similar to previous research in the field, which has shown that DSRS scores predict poorer decision making (e.g., Kinrade et al., 2015). It was concluded that slower recall occurs because using conscious knowledge when making decisions (decision reinvestment) is less efficient than unconscious processes. Furthermore, reinvestment may lead to step-by-step processing, which slows pattern recall speeds. Chapter 3 concluded that the extended recall period is detrimental as the memory trace of the pattern decays leading to poorer accuracy of the players recalled last.

In Chapter 2, the concept of decisional fit or misfit was defined. The distinction depends on whether the decision making style adopted (i.e., intuitive vs deliberate) matches the features of the situation (i.e., complexity of decision, temporal constraints etc). Research by Laborde et al (2014) discovered that intuitive athletes (measured using the Preference for Intuition and Deliberation Scale, Betsch, 2004) had a lower tendency for decision reinvestment. The deliberate (highly conscious and slower) decision making strategy adopted by high reinvestors in Chapter 3 therefore appears consistent with decisional misfit – confirmed by the poorer pattern recall accuracy observed.

Pattern recall ability represents a complex decision making process with numerous components. In Chapter 4, however, anticipating the changes of direction involved low complexity decisions, where the participant had only two choices (i.e., the attacking player could move to the left or right). The results from this study found no reinvestment associated differences in anticipation accuracy or speed. Although this seems counter-intuitive, Kinrade et al (2015) also found no decision specific reinvestment associated declines in performance of low complexity decisions. Contrary to our findings in Chapter 4, Kinrade and colleagues identified that increased scores on the rumination sub-scale of the DSRS were correlated to quicker response times on low complexity trials. However, Laborde, Raab, and Kinrade (2014) found similar results to those in the current thesis – i.e., no response

time differences between low and high decision specific reinvestors in low-complexity conditions.

The most striking finding from Chapter 4 was that MSRS scores were correlated to poorer accuracy of deceptive changes of direction. Jackson, Kinrade, Hicks, and Wills (2013) conducted the only similar study investigating whether passing accuracy in netball matches is moderated by decision or movement specific reinvestment. In direct comparison to our findings, DSRS scores, but not MSRS scores were a significant predictor of poorer performance under pressure. One possible explanation for the difference in findings is, again, the complexity of the task (low-complexity in our study vs high-complexity in Jackson et al's, 2013, study). Furthermore, unlike our methodology, Jackson and colleagues investigated real-world performances, with pressure accounted for. These contradictions highlight the need to include both the MSRS and DSRS in future research.

#### *Inattentional blindness*

The inattentional blindness paradigm is a fascinating psychological phenomenon, which is becoming increasingly popular in sporting research. Chapters 5 and 6 suggested that this phenomenon occurs in rugby and highlighted how simple tactical changes can maximize its occurrence. The previous research in this field has focused on the detrimental effect of inattentional blindness, showing how opportunities may be missed if attention is maintained by a secondary task. In this novel study, however, inattentional blindness was considered from the opposite perspective – i.e., by causing deception in opposition players.

### **Practical applications**

#### *Implicit training techniques*

The current thesis, combined with previous research, has generally shown reinvestment to be detrimental to decision making performance. For this reason, implicit learning techniques have become increasingly popular to prevent the accumulation of explicit knowledge – a critical determinant for reinvestment

(Poolton et al., 2006). Raab and Johnson (2008) described implicit learning as incidental in nature, as opposed to explicit learning, which occurs intentionally. The authors suggested that learning is never purely implicit or explicit, but rather sits on a continuum on which learning has varying contributions from each method. Implicit learning was first conceptualised by Reber (1967), defined as “a rudimentary inductive process which is intrinsic in such phenomena as language learning and pattern perception” (p. 863). Masters (1992) followed this by creating guidelines for implicit motor learning. The benefits of these implicit motor learning guidelines have been consistently shown under psychological pressure (e.g., Liao & Masters, 2001), dual task performance (e.g., Poolton, Masters, & Maxwell, 2007) and exercise-induced fatigue (e.g., Masters et al., 2008).

More recently, implicit perceptual training guidelines have been developed and researched within the sporting domain (see Jackson & Farrow, 2005 for an overview). Smeeton et al (2005), for example, compared the efficacy of different instructional techniques (which differed in their implicit and explicit contributions) for improving anticipation in tennis. In this study, the authors implemented guided discovery and discovery learning as implicit perceptual training techniques. Guided discovery is characterized as being less directed than explicit instruction, with athletes being guided to general regions (for example, the hips) to develop an understanding of cues and their outcomes. Discovery learning limits the accumulation of explicit knowledge even more by simply allowing participants to develop their own understanding of cues and outcomes without any guidance. Participants in the explicit group were given instructions about the cue location (e.g., the hips) and how the kinematics of that cue would predict the outcome (i.e., “look at the player’s backswing, see how small the backswing is in comparison to other shots” for a drop shot). Their results suggested that participants who received explicit instructions suffered significant performance decrements under anxiety provoking conditions compared to those who received implicit instructions.

Another often used technique to promote implicit learning is by manipulating attentional resources, usually through concurrent secondary tasks. These concurrent tasks have been shown to be beneficial for reducing the number of explicit rules accumulated (Masters, 1992; Maxwell, Masters, & Eves 2000; Maxwell, Masters,

& Eves, 2003). Masters (1992) proposed that learning under dual task conditions is largely implicit, as participants have limited resources at their disposal for hypothesis testing and generating rules. Importantly, Sun et al (2001) showed that the primary learning focus is retained, although at a slightly suppressed level under dual task conditions. Distraction tasks have the aim of creating incidental learning by shifting an athlete's attention from the primary learning task to a secondary task. Distraction can occur when participants believe performance is based on a particular feature, when it is actually based on another. For example, Farrow and Abernethy (2002) had participants believe the focus of the experiment was the participant's ability to anticipate the speed of a tennis serve, yet it was actually focused on predicting serve direction. The author's logic was that the relationships between body movements and serve direction would be implicitly learnt while predominantly attending to serve speed.

Lastly, analogy learning is a technique where information is conveyed in a simple form, well known to the individual. For example, in Chapter 3, it was suggested that the pattern the back three (left wing, fullback and right wing) usually take on the field could be conveyed more succinctly using the visual analogy of Newton's cradle (a pendulum). These analogies may also aid individuals when chunking large amounts of information into smaller parts (e.g. the two diamond formations shown in Figure 1). Analogy learning can also be used to implicitly learn movement patterns. For example, Liao and Masters (2001) found that participants who learnt a table tennis forehand topspin shot using an analogy (move the bat as if it is travelling up the side of a mountain) suffered fewer performance decrements in dual task and stress conditions. Fitting neatly with the current thesis, Gabbett and Masters (2011) proposed a 'Frankenstein' analogy to help defensive rugby players read a ball carrier's evasive running kinematics more effectively. This analogy suggested that players should "imagine a rod through your head and spine" (p. 568), in order to encourage them to keep their head up to watch the ball carrier for as long as possible throughout the tackle (without explicitly telling the player to do so).



### *Inattentional blindness*

As mentioned previously, it is important for sporting practitioners to understand both how to maximise the chance of inattentional blindness occurring (for deceptive purposes) and also how to minimize it (to prevent missed opportunities). Our data, combined with previous data in the field, has strong practical applications when trying to maximise the chance of the phenomenon occurring. For example, practitioners should seek to identify the key characteristics that capture opposing players' attention in their sport. These characteristics may be subtle (as in Chapter 5); however, it is now understood that displaying these characteristics can have a meaningful effect on the opposition. Furthermore, expectation and semantic congruency play a large role in inattentional blindness. Therefore, changing tactics from the norm and manipulating the congruency of certain elements can help to maximise the probability of creating inattentional blindness. Lastly, attention has been shown to vary based on factors such as age, mental aptitude or fatigue (Green, 2004). With advancements in performance analysis, practitioners/coaches could target individuals who might be most at risk to experiencing inattentional blindness.

Minimising inattentional blindness is more difficult as it is involuntary consequence of preventing information overload (Green, 2004). Training should seek to increase the conspicuity of critical information, decrease attention diverting to irrelevant stimuli and decrease the number of secondary tasks. For example, a rugby coach may promote a 'ball watching technique' when defending plays such as the ones used in Chapter 6. This would involve players tracking their opposite number using their peripheral vision, but focusing their attention on the ball solely to pick up advanced information about who will receive the ball. As mentioned previously, inattentional blindness is heavily reliant on expectation of what is likely to occur. Therefore, to reduce the likelihood of an unexpected event, coaches should seek to profile upcoming opponents using video analysis, where specific plays or trends can be shared with players.

## **Limitations**

A key limitation of the research conducted in this thesis was that participants were not tested under the influence of exercise-induced fatigue. As the majority of the decisions made in a rugby match are made under some level of fatigue, this needs to be addressed in follow up studies. Hüttermann and Memmert (2012), for example, found that physical exercise influences an individual's attention performance. The authors observed decreases in inattention blindness from resting to moderate fatigue, and increases from moderate fatigue to high fatigue. In sport, this can have huge implications for coaches - such as timing of substitutions – warranting deeper investigation.

Methodological limitations were also evident within the experimental chapters (e.g., using verbal responses for anticipatory responses in Chapter 4 and using excel for the pattern recall tasks in Chapters 2 and 3). These limitations can be easily addressed with a larger financial budget and by utilizing ever advancing technology.

## **Future directions**

The multidisciplinary nature of this thesis has raised several issues that could be addressed by future research. Perhaps the most interesting finding was identified in Chapters 5 and 6, where inattention blindness was identified as a plausible explanation for line break occurrences. As the inattention blindness phenomenon is a recent development in sporting research, further investigations should be carried in a wide range of sports and under exercise-induced fatigue. Furthermore, to ensure inattention blindness is occurring – and not simply misdirection - technology such as eye tracking should also be implemented.

The thesis investigated the role of reinvestment with differing results. The most pertinent finding from Chapter 4 was that MSRS scores were associated with poorer anticipation accuracy of deceptive changes of direction. This finding warrants the inclusion of both the DSRS and MSRS in decision making research. Ascertaining high DSRS scores were also correlated to slower and less accurate recall of patterns

provides a novel finding which deserves further investigation. This research should seek to 1) corroborate the results and 2) understand the processes underlying the key differences. Of specific interest is whether any differences in gaze behavior or methods of chunking information are evident.

Following the themes of the thesis, a combined investigation into whether inattention blindness is moderated by reinvestment would be of interest. Both reinvestment and inattention blindness are dependent upon attentional differences, providing the rationale for what would be a novel study. With regards to the findings in Chapter 4, it is unclear whether the high tendency to consciously process decisions (high reinvestment) would cause individuals to be more susceptible to the confusion caused by decoy runners or whether high reinvestors would be less susceptible, due to greater conscious awareness of the situation unfolding.

A similar phenomenon to inattention blindness is change blindness, where an individual fails to register a change in a stimulus that would normally be noticed (Rensink, 1997; Simons & Levin, 1997). For example, in Simon and Levin's (1998) study, participants failed to notice that a stranger they were conversing with had been replaced by another stranger following a brief interruption (a large object coming between them). Similar to inattention blindness, it has been shown that disruptions in attention can cause change blindness to occur and this is maximized when the change is unexpected (Levin & Simons, 1997). An example applicable to the current thesis relates to pattern recall – a team might use a certain pattern as an initial formation only to change certain elements when attention is momentarily diverted. This could be an area of future research as there is currently little knowledge of change blindness within sporting research.

Accurately measuring player's decision making for talent identification purposes continues to cause difficulty. The results in Chapter 2 showed that pattern recall tasks can differentiate experts and novices, but are not appropriate for identifying the most talented individuals within a homogeneous sample. An important consideration for future research is to make the stimuli as appropriate to the sport as possible. Similarly, testing player's pattern recall abilities under fatigue is

unresearched to date and may provide important information for coaches, practitioners and researchers. Furthermore, research should take a longitudinal approach, whereby perceptual-cognitive measures are undertaken by talented players, before being followed up after an extended period. A valid measure should be able to differentiate players based on how far they progress in their sport (for example comparing international players vs top league domestic players vs second league domestic).

## **Conclusion**

The current thesis investigated a range of decision making elements, guided by real world challenges encountered in a professional rugby organisation. The research undertaken, using some of the world's best players, has yielded some novel, applicable findings and raised many questions to be addressed in future research. Implications for coaches and practitioners have been detailed - suggesting implicit learning techniques to limit reinvestment as well as recommendations to minimise or maximise the likelihood of inattentional blindness occurring.

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# Appendices

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## Decision-Specific Reinvestment Scale (Kinrade et al, 2010)

### *Instructions:*

- *Rate how each statement characterizes your own decision-making*
  - *0 = Extremely uncharacteristic*
  - *4 = Extremely characteristic*
- *Think about instances where you are required to make decisions, such as when to pass and to whom*
- *There are no right or wrong answers*
- *Answer as honestly as possible*
- *Don't spend too long on one question*

1. I'm always trying to figure out how I make decisions
2. I'm concerned about my style of decision-making
3. I remember poor decisions I make for a long time afterwards
4. I'm constantly examining the reasons for my decisions
5. I get "worked up" just thinking about poor decisions I have made in the past
6. I sometimes have the feeling that I'm observing my decision-making process
7. I often find myself thinking over and over about poor decisions that I have made in the past
8. I think about better decisions I could have made long after the event has happened
9. I am alert to changes in how much thought I give to my decisions
10. I'm aware of the way my mind works when I make a decision
11. I rarely forget the times when I have made a bad decision, even about the minor things
12. When I am reminded about poor decisions I have made in the past, I feel as if they are happening all over again
13. I'm concerned about what other people think of the decisions I make

### **Movement-Specific Reinvestment Scale (Masters et al., 2005)**

**DIRECTIONS:** Below are a number of statements about your movements. The possible answers go from 'strongly agree' to 'strongly disagree'. There are no right or wrong answers so circle the answer that best describes how you feel for each question.

1. I rarely forget the times when my movements have failed me, however slight the failure.

Strongly disagree	Moderately disagree	Weakly disagree	Weakly agree	Moderately agree	Strongly agree
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2. I'm always trying to figure out why my actions failed.

Strongly disagree	Moderately disagree	Weakly disagree	Weakly agree	Moderately agree	Strongly agree
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3. I reflect about my movement a lot.

Strongly disagree	Moderately disagree	Weakly disagree	Weakly agree	Moderately agree	Strongly agree
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4. I am always trying to think about my movements when I carry them out.

Strongly disagree	Moderately disagree	Weakly disagree	Weakly agree	Moderately agree	Strongly agree
-------------------	---------------------	-----------------	--------------	------------------	----------------

5. I'm self conscious about the way I look when I am moving.

Strongly disagree	Moderately disagree	Weakly disagree	Weakly agree	Moderately agree	Strongly agree
-------------------	---------------------	-----------------	--------------	------------------	----------------

6. I sometimes have the feeling that I'm watching myself move.

Strongly disagree	Moderately disagree	Weakly disagree	Weakly agree	Moderately agree	Strongly agree
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7. I'm aware of the way my mind and body works when I am carrying out a movement.

Strongly disagree	Moderately disagree	Weakly disagree	Weakly agree	Moderately agree	Strongly agree
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8. I'm concerned about my style of moving.

Strongly disagree	Moderately disagree	Weakly disagree	Weakly agree	Moderately agree	Strongly agree
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9. If I see my reflection in a shop window, I will examine my movements.

Strongly disagree	Moderately disagree	Weakly disagree	Weakly agree	Moderately agree	Strongly agree
----------------------	------------------------	--------------------	-----------------	---------------------	-------------------

10. I am concerned about what people think about me when I am moving.

Strongly disagree	Moderately disagree	Weakly disagree	Weakly agree	Moderately agree	Strongly agree
----------------------	------------------------	--------------------	-----------------	---------------------	-------------------



## Co-Authorship Forms



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Chapter 2 - Pattern recall, decision making and talent identification in rugby union

Nature of contribution  
by PhD candidate

Main investigator, study design, data collection and analysis, primary author of manuscript

Extent of contribution  
by PhD candidate (%)

75%

### CO-AUTHORS

Name	Nature of Contribution
Rich Masters	Assistance with planning of study, data analysis and refining of final manuscript
Tiaki Brett Smith	Assistance with planning of study, data analysis and refining of final manuscript

### Certification by Co-Authors

The undersigned hereby certify that:

- ❖ the above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and

Name	Signature	Date
Rich Masters	<i>R. A. W. Masters</i>	30 <sup>th</sup> May 2019
Tiaki Brett Smith	<i>Tiaki Brett Smith</i>	29 <sup>th</sup> May 2019

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Chapter 3 - Decision reinvestment, pattern recall and decision making in rugby union

Nature of contribution  
by PhD candidate

Main investigator, study design, data collection and analysis, primary author of manuscript

Extent of contribution  
by PhD candidate (%)

75%

### CO-AUTHORS

Name	Nature of Contribution
Rich Masters	Assistance with planning of study, data analysis and refining of final manuscript
Tiaki Brett Smith	Assistance with planning of study, data analysis and refining of final manuscript

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Chapter 4 - Anticipating deceptive movements in rugby union: The role of reinvestment

Nature of contribution  
by PhD candidate

Main investigator, study design, data collection and analysis, primary author of manuscript

Extent of contribution  
by PhD candidate (%)

75%

### CO-AUTHORS

Name	Nature of Contribution
Rich Masters	Assistance with planning of study, data analysis and refining of final manuscript
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Chapter 5 - Examining deceptive behaviours by attackers in rugby union: The influence of decoy runners on defensive performance

Nature of contribution  
by PhD candidate

Main investigator, study design, data collection and analysis, primary author of manuscript

Extent of contribution  
by PhD candidate (%)

75%

### CO-AUTHORS

Name	Nature of Contribution
Rich Masters	Assistance with planning of study, data analysis and refining of final manuscript
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Chapter 6 - Inattentive blindness in Rugby Union: A clean break

Nature of contribution  
by PhD candidate

Main investigator, study design, data collection and analysis, primary author of manuscript

Extent of contribution  
by PhD candidate (%)

75%

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Rich Masters	Assistance with planning of study, data analysis and refining of final manuscript
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