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Anticipating deceptive movements in rugby union: The role of reinvestment

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A R T I C L E I N F O

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A B S T R A C T

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 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 than novices but 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) scores were associated with poorer response accuracy for deceptive changes of direction.

1. 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 (2010) calculated that when facing a fast serve in tennis (over 200km/h) players have 500-700ms before they attempt to return the ball. They have a very small window in which to judge the ball's direction and speed, decide on an appropriate shot, move into the right position and prepare and execute the required shot. Responding based purely on the flight of the ball (reliable information) is insufficient because human sensory processing speeds are too slow (Loffing & Cañal-Bruland, 2017). Consequently, expert performers utilise 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, Warren, & Abernethy, 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 further complicated when a player uses deception to mislead an opponent into making an incorrect decision (see Güldenpenning, Kunde, & Weigelt, 2017, for a review). Research has shown that anticipation is poorer for deceptive compared to non-deceptive movements (e.g., Mori & Shimada, 2013; Dicks, Button, & Davids, 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

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experts is thought to be superior to novices because they have greater experience in both perceiving and performing the observed actions (Cañal-Bruland, van der Kamp, & van Kesteren, 2010). Aglioti, Cesari, Romani, and Urgesi (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, Eves, & Maxwell, 2005) refers to an individual's propensity to draw upon (and reinvest) previously acquired explicit, rule-based knowledge to consciously control movements. Decision specific reinvestment (Kinrade, Jackson, Ashford, & Bishop, 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, Polman, & Hammond, 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, Jackson, & Ashford, 2015), netball (Jackson, Kinrade, Hicks, & Wills, 2013) and korfball (Kinrade et al., 2010). For example, Jackson et al (2013) found DSRS score to be a significant predictor of poorer passing completion under pressure, in a real-life netball matches. 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, Askew, and Sayers (2010) showed that 72% of tackle breaks resulted from an attacker side-stepping the defensive player. To date, the association between propensity for reinvestment and anticipation of deceptive movements has not been examined. We therefore asked whether a higher propensity for reinvestment (movement or decision) causes slower or less accurate anticipation in response to deceptive side-steps in rugby? 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. It is unclear how movement reinvestment will affect anticipatory performance, due to the novelty of this line of inquiry. However, it is hypothesised that decision reinvestment will have a deleterious effect on anticipation of both deceptive and non-deceptive movements.

2. Methods

2.1. 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 ± 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 ± 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 ± 2.49 years). Ethical approval was obtained from a university panel and all participants provided informed consent prior to involvement.

2.2. 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, so they could be viewed in a virtual reality headset.

Two highly skilled rugby players - of the same ability as the expert participants - 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 1). 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 Deceptive Trials, players feinted towards one target before changing direction to run towards the other target. In Non-Deceptive trials, players changed direction towards one of two targets located at an angle of 45° (triangles below). Players were filmed multiple times running to both the left and the right.

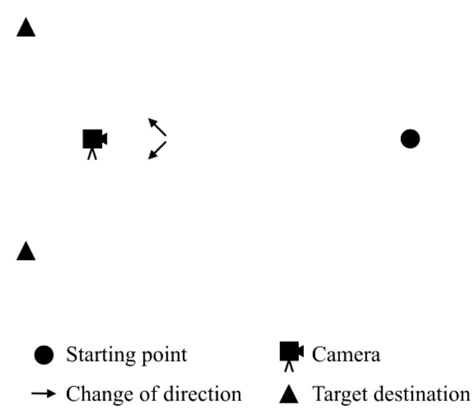

Figure 1: A visual representation of the filming set up used

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 2 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, including Deceptive Trials (N=60) and Non-Deceptive Trials (N=60). Twenty Deceptive and twenty Non-Deceptive trials were randomly occluded at each of the three time points.

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 clips (allocated in a random order using a random sequence generator) that included deceptive trials (N=10) and non-deceptive trials (N=10).

Figure 2: The final frames of a non-deceptive trial (top row) and a deceptive trial (bottom row) occluded at T1 (left), T2 (middle) and T3 (right).

2.3. Test procedure

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 (and individual's propensity to consciously engage in controlling their movements). Acceptable internal consistency has been reported for both movement self-consciousness (α = .79) and conscious motor processing (α = .71) (Masters et al, 2005). 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). Acceptable internal consistency has been reported for both decision reinvestment (α = .89) and decision rumination (α = .91) (Kinrade, Jackson, Ashford, & Bishop, 2010). For both the MSRS and the DSRS, scores on each sub-scale can be computed or a global propensity score can be examined.

In the test procedure, participants viewed each trial 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. Following technological advancements in recent years, VRVR has become increasing popular as a method to mirror real life scenarios more closely (e.g., Bideau, Kulpa, Vignais, Brault, Multon, & Craig, 2010; Stinson & Bowman, 2014).

Participants first completed a block of practice trials before completing the blocks of experimental trials (allocated in a random order using a random sequence generator). The practice trials familiarised participants with the apparatus and test procedure, with any questions answered prior to completion of the test trials. All blocks were completed in one session (approx. 20 min). 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. Other studies have chosen to adopt movement tracking to measure participants' responses (e.g. Brault, Bideau, Kulpa, & Craig, 2012). However, due to the exploratory nature of the current investigation the authors believed verbal responses would be sufficient in this case, with promising findings warranting more sophisticated methodologies in follow up studies.

Following each block of trials, the VR headset was removed and participants rested for approximately 2 min (based on personal preference) 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 judge the realism of footage, ranging from 1 (completely unrealistic) to 10 (completely realistic) to ascertain the fidelity of the methodology for future studies.

2.4. 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 in the form of Bonferroni corrected pairwise comparisons 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.

3. Results

3.1. Response Accuracy

The mean Response Accuracy scores for Deceptive and Non-Deceptive trials are shown in Figure 3. 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 significant difference was found between 0ms and +100ms ($p > 0.05$). For Skill Level, the only significant 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 < 0.05). No further two-way or three-way interactions were evident (p's > 0.05).

3.2. Response Time differences

The mean Response Times for Deceptive and Non-Deceptive trials are shown in Figure 4. 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 ($p < 0.05$). For Occlusion Point, Response Times were significantly slower in -100ms trials than 0ms trials ($p < 0.05$). The main effect for Skill Level found that experts were significantly slower than novices ($p < 0.05$). No significant two-way or three-way interactions were found (p's $>$ 0.05).

3.3. 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 > 0.05). 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).

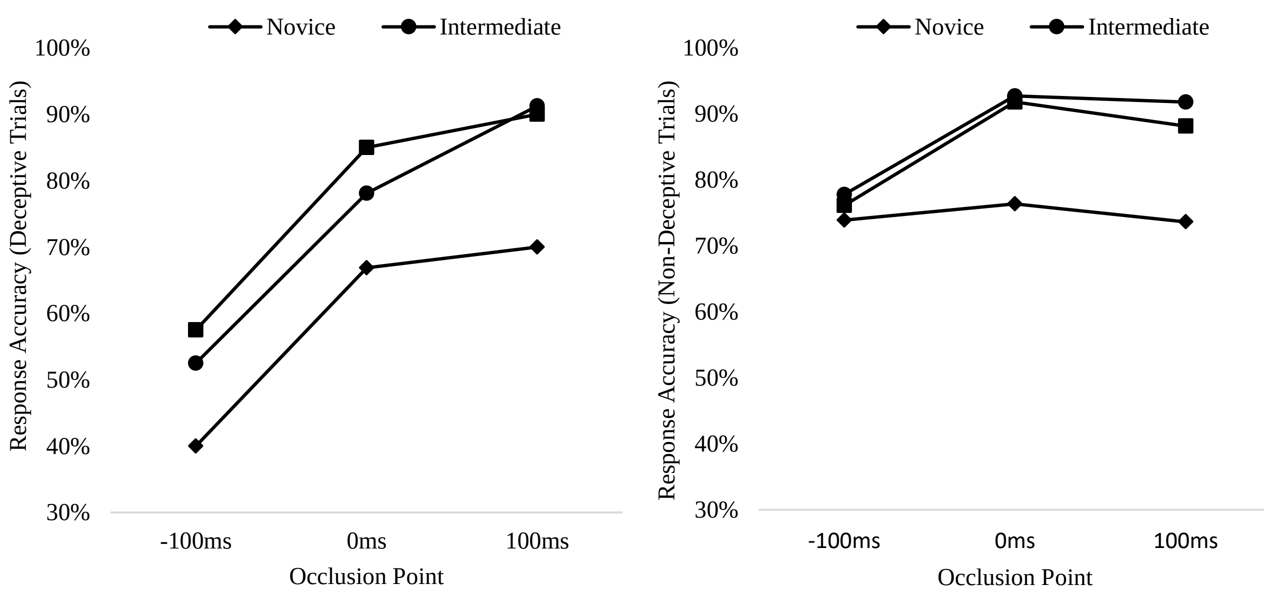

Figure 3: Mean Response Accuracy scores on Deceptive trials (left) and Non-Deceptive trials (right) at each occlusion point

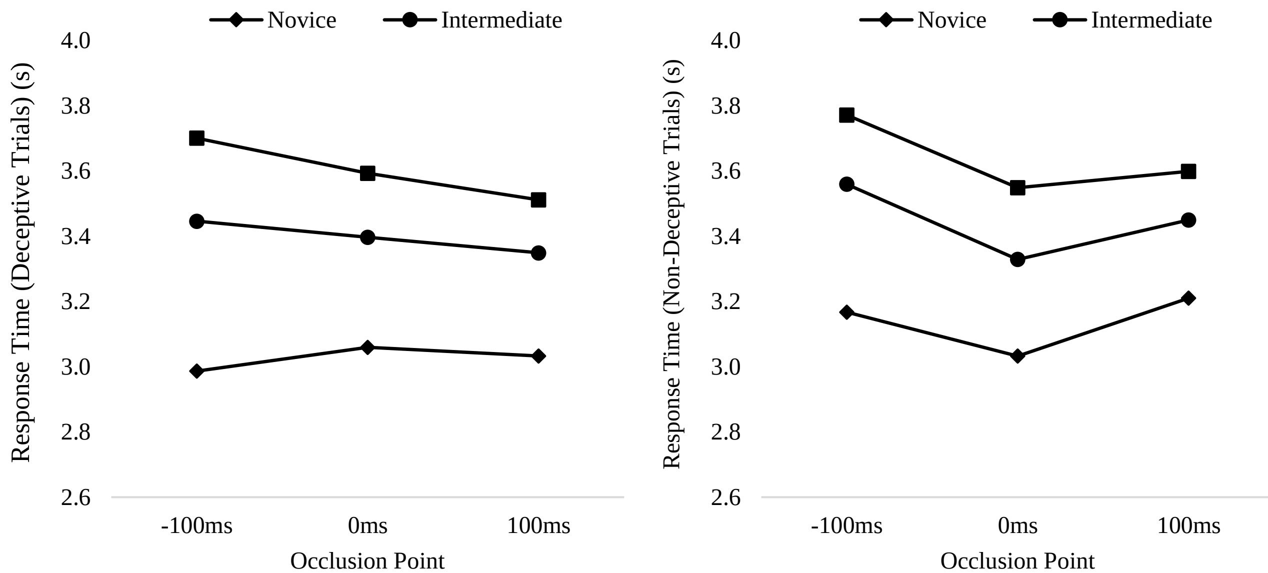

Figure 4: Mean response times on Deceptive trials (left) and Non-Deceptive trials (right) at each occlusion point

3.4. 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).

4. 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. We believe the study undertaken has improved the understanding of anticipation, especially in relation to skill level and reinvestment.

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, Jackson, & Wang, 2010; Cañal-Bruland, et al., 2010). Throughout the analysis, intermediates' Response Accuracy or Response Time were not significantly different to the other skill levels. The superiority of experts, compared to novices, could be due to greater experience of perceiving and performing such actions (Cañal-Bruland et al., 2010), which allows them to more effectively comprehend the 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.

Consistent with previous research, accuracy when anticipating both deceptive and non-deceptive changes of direction was highest when trials were occluded later. Consequently, experts were more accurate that 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, Zawi, & Jackson, 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. (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 was 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 as per 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. This differs from findings such as Jackson et al's (2013), where DSRS scores were found to be a significant predictor of poorer passing under pressure in netball. However, the results observed may be due to the low complexity of the task (i.e., the viewed 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. This suggests that decision specific reinvestment may only have a deleterious effect on high-complexity decisions.

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. It is also possible that the high reinvestors responses are more likely to suffer performance decrements because of the psychological refractory period (Schmidt & Wrisberg, 2008), during which the second stimulus (underlying kinematics of the actual running destination) cannot be processed until the deceptive kinematics have been fully processed (most likely in a conscious and more timely manner). 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 responses 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). This would allow researchers to assess the effect of reinvestment throughout the decision making process - not just the final decision, as in the current study. Future studies should also implement a range of side-step types (i.e., single and double). With regard 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 in areas such as immersive learning or skill acquisition.

5. 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). The current investigation uncovers some novel findings that future research should seek to clarify while examining the underlying mechanisms.

Conflict of Interest

The authors declare no conflict of interest.

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