The effects of skill-level and playing-position on the anticipation of ball-bounce in rugby union

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Abstract

The ability to anticipate is a defining feature of skilled sports performance. To date, research investigating the information that underpins skilled anticipation has focused on kinematic information from an opponent and contextual factors. However, there has been a paucity of research investigating the influence of ball-flight and spin. Oval shaped balls, despite the seeming random nature, do in fact display specific bounce characteristics based on the nature of ball-flight. We tested the ability of 38 professional (categorised in to 15 'backs' and 23 'forwards' based on their playing position) and 20 less-skilled rugby union players to anticipate ball bounce direction for grubber and chip kicks using a temporal occlusion paradigm to restrict access to different sources of information. We predicted that skilled performers would have become attuned to both advance postural cues and the physical laws of ball flight and spin that govern ball bounce through their extensive practice and exposure to these situations, and so would anticipate more accurately than less-skilled performers. Results supported this hypothesis as skilled participants outperformed less-skilled in all occlusion conditions, however all groups anticipated more accurately with access to later emerging information sources (i.e., ball spin and rotation) with the skill level difference primarily underpinned by earlier available sources (i.e., advance postural cues). There was no difference between anticipation accuracy in professional forwards and backs and no kick type x group interaction, suggesting that the knowledge structures underpinning perceptual-cognitive expertise are not position specific. Findings have implication for models of anticipation and training design and tactics in rugby.

Key words: expertise, perceptual-cognitive skills, rugby, anticipation

1. Introduction

The ability to anticipate future events is a defining characteristic of elite performers in a variety of domains (e.g., healthcare, Currie & MacLeod, 2017; finance, Rodgers & McFarlin, 2017; sport, Williams, Ford, Eccles, & Ward, 2011). In sport, the importance of anticipation is magnified given the dynamic nature of the environment and the strict time constraints under which performers must operate. To date, researchers have focused on how experts pick-up kinematic cues (Savelsbergh, van der Kamp, Williams, & Ward, 2005), recognise global patterns of play (North, Hope, & Williams, 2016), or utilise contextual information (Murphy et al., 2016) to inform anticipation judgments ahead of the event. However, in certain sports, performers are faced with situations that appear to prevent them from proactively anticipating or 'reading' the situation and instead force them to react after the event (e.g., the shape of an oval ball such as that used in sports like rugby union, rugby league, Australian rugby football, and American football can appear to bounce in a random fashion, which seemingly prevents anticipation of bounce direction). In rugby union the number of possessions kicked and the numbers of errors made during a game can predict outcomes of close matches, (Vaz, van Rooyen & Sampaio, 2010; Vaz, Mouchet, Carreras & Morente, 2011) with around 32 kicks from hand remaining in play each game and therefore requiring fielding (Eaves, Hughes & Lamb, 2005). More recent analysis of the 2015 Rugby World Cup revealed an average of 27 kicks out of hand were performed in each match (Lazarczuk, 2019). Given how frequently kicks from hand are performed in rugby union, it is surprising that we know little about the skills involved in fielding such kicks, particularly when players are often required to anticipate the outcome of an oval ball bouncing on the ground. In the present study, we examined whether elite performers in such a domain were able to accurately predict and demonstrate skilled anticipation of ball-bounce by employing a temporal occlusion paradigm that manipulated access to different sources of information.

Much of the scientific study of expert performance is rooted in Ericsson, Krampe, and Tesch-Römer’s (1993) theory of deliberate practice in which it is argued that expertise develops as a result of extensive domain-specific deliberate practice. Theories of expert memory propose that this extended engagement results in changes in cognitive knowledge structures which direct attention to the most pertinent information sources, ensure irrelevant display features are disregarded, and facilitate more efficient encoding, storage, and retrieval of information (e.g., see Long Term Working Memory theory, Ericsson & Kintsch, 1995). The implication, from a sporting perspective, is that extensive domain-specific practice enables attention to be quickly directed to the most important postural cues or groups of features (patterns), which are quickly encoded and judged relative to previously encountered and stored information, in turn enabling quick and accurate anticipation (Abernethy, Farrow, Gorman & Mann, 2012; North, Williams, Hodges, Ward & Ericsson, 2009; Roca, Ford, McRobert & Williams, 2013; Williams, Huys, Cañal-Bruland, & Hagemann, 2009). In rugby, differing kicker kinematics can lead to different patterns in the flight of the ball (Atack, Trewartha & Bezodis, 2019; Sinclair et al., 2017). Therefore, skilled players are likely to develop the ability to use cues from the kicker’s body to anticipate the outcomes of kicks.

While skilled performers utilise information from postural cues, patterns, and context to anticipate, skilled sports people have also been reported to make use of information from early periods of ball-flight to accurately anticipate or adjust and modify their decisions. For example, in cricket, early ball-flight can be used to anticipate the nature of a delivery from spin and seam bowlers (Müller & Abernethy, 2006; Müller et al., 2009). Runswick, Roca, Williams, McRobert and North (2018a) edited video footage to present different sources of information (game context, the bowler’s postural cues, and ball-flight) to cricket batters and asked them to anticipate where the next delivery would pass the stumps. Findings showed skilled batters outperformed lesser skilled counterparts at all occlusion points, with anticipation performance being most accurate when all sources of information were available. Where the information available is consistent and predictable (both postural cues and ball-flight) in relation to event outcome, skilled performers are able to utilise their cognitive knowledge structures to inform judgments about how information available in the present is likely to inform future events. However, when dealing with a kick bouncing off the ground in rugby union, the perceived lack of consistency given the oval shape of the ball may undermine skilled performers' ability to make anticipation judgments and utilise early emerging information.

Despite this perceived lack of consistency in the bounce characteristics of an oval ball, Cross (2010) has in fact reported physical laws based on the angle, height, speed, and rotation of the ball that inform how an oval shaped ball will bounce. Specifically, (1) an oval shaped ball with topspin will bounce to a greater height backwards than forward, (2) an oblique angled projection will lead to a vertical bounce if impact with the ground is between 20-60°, and (3) the ball projected at an oblique angle with backspin will result in either a forward bounce with top spin when leaning forward at impact or a backward bounce with topspin when leaning backward at impact. In line with theories of expert memory that propose domain specific knowledge structures develop through extended practice and enable attunement to critical information cues/sources (cf. Ericsson & Kintsch, 1995), elite level rugby players will have had extended engagement in rugby specific practice, play, and competition, and will have fielded considerable numbers of bouncing balls and so it is possible they may become implicitly attuned to these physical laws that govern ball-bounce characteristics. If this is the case, skilled rugby players would be expected to show superior anticipation than less-skilled performers through understanding the relationship between kicking kinematics and ball-flight patterns and the subsequent influence of ball-flight pattern on bounce direction. However, with these laws focusing primarily on vertical bounce, it should be easier for skilled rugby players to predict the height of ball bounce as opposed to its lateral direction.

A feature of rugby union, like other team sports, is that teams are comprised of a combination of players with specific positional responsibilities. Researchers testing theories of expert memory have published a considerable body of evidence to support the proposal that expert memory is domain specific (e.g., see Allard, Graham, & Paarsalu, 1980; Chase & Simon, 1973; Gobet & Campitelli, 2007; Starkes, 1987; Werner & Thies, 2000). However, recently researchers have suggested that expertise may not just be domain specific, but can be further specified based on specific experiences within the domain. For example, Kirkman (2013) suggested, in a review of surgical literature, that expertise in surgery is specific to the procedure and the context in which it is being executed, to the extent that expertise may be specific to the hospital in which a procedure is executed (see Huckman & Pisano, 2006). Through their engagement in position-specific practice it is likely that rugby players will develop knowledge structures that are not just sport specific, but are position specific also. Whilst there is considerable evidence for the domain specific nature of expertise, the degree of specificity of the knowledge structures underpinning expertise warrants further investigation and to examine if suggestions from other domains (see Kirkman, 2013) transfer to position specificity in sport.

In rugby union, players are typically characterised as being either ‘backs’ or ‘forwards’. The nature and requirements of these positions, means that both are likely to have experience in dealing with kicks along the ground (often referred to in the sport as grubber kicks) whereas only ‘backs’ will typically have extensive experience in fielding kicks that are played through the air with prolonged ball-flight (such kicks are kicked over the heads of forward players and so they would typically not have to field these). Therefore, based on theories of expert performance and expert memory, and the specific nature of expertise, we expected that players in both positions would have developed knowledge structures that allow them to anticipate grubber kicks, whereas only ‘backs’ will have developed such refined cognitive knowledge structures to anticipate bouncing balls following kicks played through the air. Understanding these differences could provide tactical advantages when kicking out of hand when faced with a certain type of opposing player in match play situations.

The expert performance approach (Ericsson & Smith, 1991; Williams & Ericsson, 2005) provides a framework for guiding research investigating expertise and has been widely applied to investigations of perceptual-cognitive skill in sport (see McRobert, Williams, Ward, & Eccles, 2009; Roca, Williams & Ford, 2014). The framework recommends three stages; the first stage is to capture expert performance (evidenced through tasks that capture skill level differences). The second stage involves identifying underlying mechanisms of expertise captured in stage one. The final stage is to examine how expertise is developed through practice histories and interventions. Given the absence of research that has investigated situations requiring an anticipatory response to an oval shaped ball and whether this skill is indeed mediated by expertise, we sought to initially focus on stage one of the expert performance approach to capture expertise to establish if the task of anticipating ball-bounce in rugby is underpinned by expertise and whether this expertise is specific to playing position. Beyond this, by restricting access to different information sources through a temporal occlusion paradigm we were able to provide insights as to *what* information was utilised by participants to inform their anticipation judgments (i.e., stage two).

Our first aim in this study was to examine the anticipation ability of professional forwards and backs and less-skilled rugby union players in predicting the direction and height of ball-bounce following kicks in rugby union, and also examined if this ability was affected by different types of kick. Secondly, we employed a temporal occlusion method with the aim of identifying the information that was important to making accurate predictions of ball bounce direction. On the basis of laws that predict bounce direction of an oval ball (Cross, 2010) and theories of expert performance and expert memory proposing that extended practice would enable performers to attend to critical sources of information that inform likely event outcomes, we predicted that skilled rugby union players (forwards and backs) would demonstrate superior anticipation accuracy than less-skilled players. This advantage would be most pronounced when anticipating vertical bounce direction. We predicated, based on previous findings (e.g. Runswick et al., 2018a), that both postural cues and ball-flight information would contribute to anticipation of ball bounce direction and the highest accuracy would be observed when both information sources were available. While both ‘forwards’ and ‘backs’ were expected to accurately anticipate kicks along the ground (grubber kicks), only ‘backs’ were predicted to be able to accurately anticipate ball-bounce from kicks delivered through air, given that only ‘backs’ typically experience dealing with such kicks in training and game situations.

2. Method

2.1 Participants

Altogether 38 skilled professional (age 25.9 ± 3.4 years; experience 11.9.1 ± 6.8 years) and 20 less-skilled (age 22.4 ± 3.6 years; experience 1.9 ± 2.2 years) rugby union players participated in the study. Participants that were currently competing at a professional level were deemed as the most likely to have developed position specific expertise and were further split in to two groups according to their position; backs (N = 15) and forwards (N = 23). At the time of testing, the professional participants were competing at RFU Championship level rugby (the second tier of English professional rugby) and accumulated a mean weekly playing time of 13.5 ± 8.4 hours. 17 participants had experience at a higher level (Premiership or International rugby). At the time of testing, the less-skilled participants were not playing competitive rugby and had no history of competitive rugby playing experience beyond recreational participation and compulsory school classes. Ethical approval was obtained from the lead university ethics committee. Participants provided fully informed written consent prior to testing.

2.2 Stimuli

Video stimuli were created using a right-footed University First XV rugby union player who executed both grubber and chip kicks on a grass rugby field with a size five rugby ball (Gilbert Photon). Following discussion with coaches and in order to simulate the position of a full back defending close to their own goal line, kicks were executed in the direction of the camera from 15 m away. The Panasonic HC-V210 HD camcorder recording at 50Hz (Panasonic UK Ltd., Berkshire, UK) was set on a tripod at eye-level at a height of 1.7m and angled downwards 10° to replicate the perspective of a defender. Clips were included if the ball contacted the ground in a 4 m x 4 m target area of the pitch 3 m perpendicular to the camera's lens. Overall, 23 grubber kicks and 14 chip kicks met the criteria. iMovie (Version 10.1.4) was used to edit and occlude the video of each kick at three different time points. We chose to repeat clips across three occlusion points to negate effects of different levels of trial difficulty (e.g. Runswick et al., 2018c). Therefore, a total of 111 video clips were used (mean length 2.4 ± 1s). The 111 clips were organised randomly into one 20-minute test video, so any kick type and occlusion condition could appear to the participant. After randomisation, the order was checked to ensure repeated clips were not displayed one after another. To avoid familiarisation with repeated clips, participants were not informed that any clips were repeated and were simply asked to respond to the 111 separate trials from the same kicker. No participants reported seeing repeated trials. To enhance the representative nature of the footage and ensure probabilities based on kicking technique were present, the distribution of potential kick outcomes was not controlled. Instead all kicks that bounced in the target location were included and the final distribution of outcomes is presented in Table 1.

2.3 Occlusion Conditions

The three temporal occlusion conditions were: (i) *postural-cues only*, footage showed the player preparing to kick and was then occluded at the frame immediately prior to foot-to-ball contact; (ii) *postural-cues and ball-flight,* footage showed the player preparing to kick, strike the ball, and the subsequent ball-flight, and then being occluded at the last frame of ball-to-ground contact within the target area; (iii) *ball-flight only*, showing only footage from the point of foot-to-ball contact to last frame of ball-to-ground contact in the target area. A familiarisation test film was created using the same process and included one clip per condition (chip postural-cues only, chip postural-cues and ball-flight, chip ball-flight only, grubber postural-cues only, grubber postural-cues and ball-flight, and grubber ball-flight only).

2.4 Procedure

After providing written informed consent, participants viewed the familiarisation video. The full-length temporal occlusion anticipation test video was then displayed on a white wall to create a large 5 m × 3.5 m projected image using a Sanyo PDG-DET100L Projector (Sanyo Electric Co Ltd., Osaka, Japan). Participants completed the test alone or in small groups based on availability of the professional players around their training schedule. Where small group testing was undertaken, participants were seated apart and square on to the screen. For each clip, participants were instructed to predict via pen and paper response the horizontal (left, middle or right) and vertical (high or low) direction they believed the ball would bounce to after the last ball-to-ground contact. The horizontal direction was defined as the placement within the video image from the participant's perspective (see Figure 1) and was selected based on where a movement response would be required to the left or right to field the ball. The vertical direction was defined as being high if the ball-bounced into the top two thirds of the screen (meaning participants would receive the ball at chest height or above), and low if the ball-bounced in the bottom third (meaning participants would need to lower their chest to receive the ball). Participants were provided with a visual illustration of these zones and the corresponding responses prior to being shown any footage (see Figure 1) and the opportunity for questions was provided following the familiarisation footage.

2.5 Dependent Measures

Horizontal anticipation accuracy was determined by the percentage of trials in which participants correctly selected the left, middle or right panel for the final ball location. *Vertical anticipation accuracy* was determined by the percentage of trials in which participants correctly selected high or low bounce.

2.6 Data Analysis

Each dependent variable (vertical and horizontal accuracy) was analysed using separate 3 Group (less-skilled, professional backs, professional forwards) x 2 Kick Type (grubber, chip) x 3 Occlusion Condition (postural-cues only, postural-cues and ball-flight, ball-flight only) factorial analyses of variance (ANOVA) with repeated measures on the last two factors. A Bonferroni adjustment was employed when multiple comparisons were being made in order to lower the significance threshold and avoid Type I errors (McLaughlin & Sainani, 2014). Violations of sphericity were corrected for by adjusting the degrees of freedom using the Greenhouse Geisser correction when epsilon was less than 0.75 and the Huynh-Feldt correction when greater than 0.75 (Girden, 1992). Partial eta squared (η_p^2) was used as a measure of effect size for all main effects and interactions. Cohen's d was used as a measure of effect-size for post-hoc tests and for interpreting interactions. The alpha level was set at 0.05 for all statistical tests.

3. Results

3.1 Vertical Anticipation Accuracy

For vertical anticipation accuracy, chance level was 50% with anticipation accuracy above chance in all conditions apart from the less-skilled group predicting the outcome of chip kicks with only postural cues available (see Figure 2).

Main Effects There was a significant main effect of group on anticipation accuracy in the vertical bounce direction F (2, 55) = 7.05, $p < 0.01$, $\eta_p^2 = 0.20$). Post hoc comparisons show that both professional backs (Mean ± SD; 95% CI: 63.68% ± 9.48; 60.86 – 66.45) and forwards

(63.16% ± 9.02; 60.90 – 65.41) were more accurate than the less-skilled group (58.35 ± 10.92; 55.35 – 60.19, p's < 0.001; see Table 2 for full descriptive statistics). There was a main effect of kick type, (F (1, 55) = 120.48, p < 0.001, η_p^2 = 0.69), with participants significantly more accurate in anticipating grubber kicks (67.0% ± 8.2%; 65.07 – 68.06) than chips (56.5% ± 11.4%; 54.59 – 58.39, p < 0.0001). A significant main effect of occlusion condition was also found (F (2, 110) = 8.51, p < 0.001, η_p^2 = 0.13). Post hoc comparisons revealed that participants were less accurate in the postural-cues only condition (58.46% ± 11.2%; 55.95 – 60.95) compared to the postural-cues and ball-flight (63.3% ± 8.7%; 61.34 – 65.27; p < 0.01, d = 0.48) and the ball-flight only conditions (63.4% ± 9.5%; 61.08 - 64.54; p < 0.01, d = 0.48).

Interactions There were no significant interactions between kick type and group (F (2, 55) = 0.373, p > 0.05, η_p^2 = 0.013), occlusion condition and group (F (4, 110) = 0.330, p > 0.05, η_p^2 = 0.01) or kick type and occlusion condition (F (2, 54) = 1.71, p > 0.05, η_p^2 = 0.03). The three-way interaction between group, kick type and occlusion condition approached significance with a small to moderate effect size (F (4, 110) = 2.30, p = 0.06, η_p^2 = 0.08).

3.2 Horizontal Anticipation Accuracy

For horizontal anticipation accuracy, chance level was 33.33% with anticipation accuracy above chance in all conditions apart from all groups predicting the outcome of chip kicks with only postural cues available (see Figure 3).

Main Effects There was no significant main effect of group in the horizontal direction (F (2, 55) = 0.92, p > 0.05, η_p^2 = 0.03; see Figure 3). However, there was a main effect of kick type, (F (1, 55) = 83.17, p < 0.001, η_p^2 = 0.602), with participants significantly more accurate at predicting horizontal bounce direction for grubber kicks (Mean ± SD; 95% CI: 67.0% ± 9.1%; 65.32 – 68.70) than chips (56.7% ± 12.2%; 54.71 – 58.77). There was a significant main effect of occlusion condition on horizontal anticipation accuracy (F (2, 54) = 581.06, p < 0.001, η_p^2 = 0.92). Post hoc comparisons revealed that participants were less accurate in the postural-cues only condition (36.2% ± 10.5%; 34.36 – 37.98) compared to the postural-cues and ball-flight (73.6% ± 10.6%; 71.41 – 75.76, $p < 0.001$, $d = 3.44$) and the ball-flight only conditions (75.9% ± 10.8%; 73.52 – 78.22, $p < 0.001$, $d = 3.54$). There was no difference in anticipation in anticipation accuracy between the ball-flight only and the postural-cues and ball-flight condition ($p > 0.05$, $d = 0.22$).

Interactions There was no significant interaction between kick type and group (F (2, 55) = 2.64, $p > 0.05$, $\eta_p^2 = 0.09$), occlusion condition and group (F (4, 110) = 1.73, $p > 0.05$, $\eta_p^2 = 0.06$). The kick type and occlusion condition interaction approached significance with a small effect size (F (2, 54) = 3.03, $p = 0.052$, $\eta_p^2 = 0.05$). However, there was a significant three-way interaction between kick type, occlusion condition and skill level (F (4, 110) = 6.49, $p < 0.001$, $\eta_p^2 = 0.19$). Skilled backs (48.1 ± 8.1; 43.03 – 53.20, $d = 1.41$) and skilled forwards (47.1 ± 10.0; 42.96 – 51.18; $d = 1.20$) were more accurate than less-skilled (34.6 ± 10.830.16 – 38.97) when anticipating the horizontal bounce direction of grubber kicks in the postural-cues only condition (see Figure 3).

4. Discussion

In this study, we examined the anticipation ability of skilled (professional) and less-skilled rugby union players in predicting the direction and height of ball-bounce following grubber and chip kicks and employed a temporal occlusion method to manipulate the sources of information available to inform these decisions. On the basis of laws that predict bounce direction of an oval ball (see Cross, 2010) and theories of expert performance (e.g., Ericsson, Krampe, & Tesch-Römer, 1993) and expert memory (e.g., Ericsson & Kintsch, 1995) that propose how domain specific knowledge structures developed as a function of practice allow attention to be directed to the most critical information sources, we predicted that skilled rugby union players would demonstrate superior anticipation accuracy than less-skilled players, particularly in the vertical direction. We also predicted, based on previous findings (e.g.

Runswick et al., 2018a), that both postural cues and ball-flight information would contribute to anticipation and the highest anticipation accuracy would be observed when all information was available. We also hypothesised that knowledge structures developed through practice (cf. Ericsson & Kintsch, 1995) would not only be domain specific, but also position specific on the basis of findings reported in medical surgery (Huckman & Pisano, 2006). We predicted that the position specific nature of cognitive knowledge structures underpinning expertise would be manifested through a position x kick type interaction. While we expected both 'forwards' and 'backs' to accurately anticipate kicks along the ground (grubber kicks) given that both positions are exposed to these kicks, only 'backs' were predicted to be able to accurately anticipate ball-bounce from kicks delivered through air, given that only 'backs' typically experience dealing with such kicks in training and game situations.

Consistent with our first hypothesis, both groups of professional players were significantly more accurate in anticipating the bounce of a rugby ball than less-skilled participants, but only in the vertical direction. This suggests that the task we employed was successful in capturing expert performance (see Ericsson & Smith, 1991; Williams & Ericsson, 2005) and that anticipation of the bouncing oval shaped rugby ball is a feature of expertise in this domain. These group differences support predictions from theories of expert memory (e.g., long term working memory theory, Ericsson & Kintsch, 1995) that the cognitive knowledge structures developed in experts through their extended practice and engagement within a domain enables pick-up of critical information to inform decisions and judgments. The findings also further current understanding of perceptual-cognitive expertise by demonstrating that the pick-up of such critical information applies not only to perceiving postural cues (see McRobert, Williams, Ward, & Eccles, 2009) and recognising patterns (see North, Hope, & Williams, 2016), but also perception of physical laws concerning ball flight, rotation, and spin to inform anticipation.

Further to these findings relating to our aim of capturing expert performance, we also recorded anticipation accuracy using a temporal occlusion method to manipulate access to different sources of information. The most pronounced differences in anticipation performance between skill levels were evident at the earliest occlusion point (postural cues only condition), however anticipation accuracy improved for both skilled (forwards and backs) and less-skilled participants when ball flight information was available. These findings allow us to make suggestions as to *what* cues performers are utilising and *how* they are making their anticipation judgments. The differences in the postural cues only condition suggests that professional players use advance postural cues to anticipate subsequent ball bounce, which is consistent with a large body of literature previously reported in numerous sports (e.g., tennis, Williams, Ward, Knowles & Smeeton, 2002; soccer, North et al., 2009; cricket, Runswick et al., 2018b). However, information from ball flight also appears to be relevant and is used to supplement that from postural cues to enhance anticipation accuracy further, which is consistent with recent research investigating anticipation in cricket (see Runswick et al., 2018a). However, some caution must be borne in mind with these interpretations as the temporal occlusion method we employed only provides an indirect measure of the processes underpinning expert performance. Researchers who are interested in continuing this research focus are recommended to employ more direct process tracing methods such as eye movement recording in order to allow firmer conclusions about the processes underpinning expertise in these tasks.

Researchers who have previously investigated anticipation in sport have typically focused on tasks that are performed under extreme time constraints and where actions need to be initiated prior to, or close to, the point of ball release or contact (e.g., facing a fast bowler in cricket, Müller et al., 2009; facing a penalty kick in soccer, Savelsbergh et al., 2005). The nature of such performance constraints necessitates that attention is focused on extracting information from advanced sources (such as postural cues) with only fine adjustments being updated during ball-flight (Müller & Abernethy, 2012). When anticipating ball bounce in rugby union, players could make early movements to predicted outcome locations by utilising information from postural-cues. However, the task is less time constrained than those typically investigated in sporting anticipation literature and the performer is therefore not required to be so reliant on early available information from advanced postural cues. Instead, the task constraints afford performers the opportunity to attend to information emerging after ball contact such as the angle and spin of the ball during ball-flight (Alam, Subic, Watkins, & Smits, 2009). The results that we have presented here suggest that skilled rugby union players utilise *both* advance postural cues *and* ball flight information to anticipate bounce direction of an oval shaped ball.

In relation to playing position, contrary to our hypothesis the results revealed no differences between forwards' and backs' anticipation accuracy. Although Kirkman (2013) reviewed evidence to suggest that expertise in the domain of surgery is sensitive to the context and procedure that is executed, our findings have failed to support the suggestion that position specific differences in expertise would reveal differences in anticipation performance across different types of kick. This finding shows some consistency with results reported by Williams. Ward, Ward and Smeeton (2008) who found that soccer defenders were more accurate than attackers when making anticipation judgments regardless of whether the display showed footage a from a defensive or attacking perspective. However, here we did not find any difference between positions regardless of kick type.

In addition to the effects of skill level and occlusion condition, the results also revealed that the type of kick affected anticipation accuracy. Ball bounce direction was easier to anticipate from grubber kicks than chip kicks. The occlusion points in the test stimuli were matched for all kick types, however during a grubber kick the ball interacts with the ground more frequently than a chip kick. For grubber kicks, the ball is struck directly into the ground, whereas for chip kicks it is struck upwards initially and only contacts the ground once before requiring a response from the athlete. This reduction in contact time with the ground may reduce the information that emerges from ball flight and consequently led to a negative impact on anticipation performance for chip kicks. Similar findings have been reported in other sports such as cricket, where ball-bounce further from the responder has been shown to enhance anticipation accuracy (see Müller & Abernethy, 2006; Müller et al., 2009). Here we have found that while information is gained from ball-flight in chip kicks, information gained from previous ball-bounces in grubber kicks is richer and more useful for informing anticipation. This implies that, when possible, executing chip kicks rather than grubber kicks may be more valuable for attacking teams.

Much research investigating perceptual-cognitive expertise is often criticised for the true lack of expertise in ‘expert’ samples (see Swann, Moran & Piggott, 2015) and the low sample sizes used in expert groups (see Schweizer & Furley, 2016). In this study we overcame these limitations by recruiting a large sample size of professional players. We have provided an insight to the nature of perceptual-cognitive expertise in rugby union and extended current understanding by showing that postural cues are still utilised to inform an expert advantage in tasks with longer ball flight phases and even when this ball flight is an oval ball. Skilled performers also use information from ball flight to supplement that which is extracted from postural cues to enhance anticipation accuracy further still. However, we did not record process tracing measures such as visual search behaviour, and we would recommend that researchers seek to employ such methods in future investigations in order to more directly address Stage 2 of the expert performance approach. In this study we also employed pen and paper responses, with some researchers arguing that this uncouples the functional links between perception and action (see Pinder, Davids, Renshaw & Araújo, 2016; van der Kamp, Rivas, van Doorn, & Savelsbergh, 2008). However, in-situ tasks can result in a lack of experimental control, and in seeking to experimentally examine the perceptual information used to inform perceptual anticipation judgments a screen based paradigm that used pen and paper responses enabled us to do this. Nevertheless, researchers are increasingly striving to use more representative tasks and modes of response (e.g., see Runswick et al, 2018b), and so alongside the collection of process tracing measures, researchers may also wish to consider using more representative or in-situ tasks in future investigations.

The results presented in this study contribute to empirical developments in the field of expert performance and perceptual-cognitive expertise and have implications for applied practice. Current models of skilled anticipation in sport have focused almost exclusively on perception of advanced cues through the use of postural/kinematic information (Savelsbergh et al., 2005) and pattern-recognition (North et al., 2009; Roca et al., 2013). Here, however, we have shown that in anticipation tasks which involved executing a response at a time that allows for more ball-flight to be viewed, information is still gained from advance postural-cues but is then supplemented by information emerging from ball flight to enhance anticipation accuracy further still. Furthermore, by investigating forwards and backs playing at the same level we have presented new evidence to suggest that the development of perceptual-cognitive skill in sport is domain, but not position, specific. From a practical perspective, results suggest that chip kicks are likely to be more difficult for defenders to intercept successfully; suggesting chip kicks may be more tactically advantageous than grubber kicks during attacking situations.

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Figures

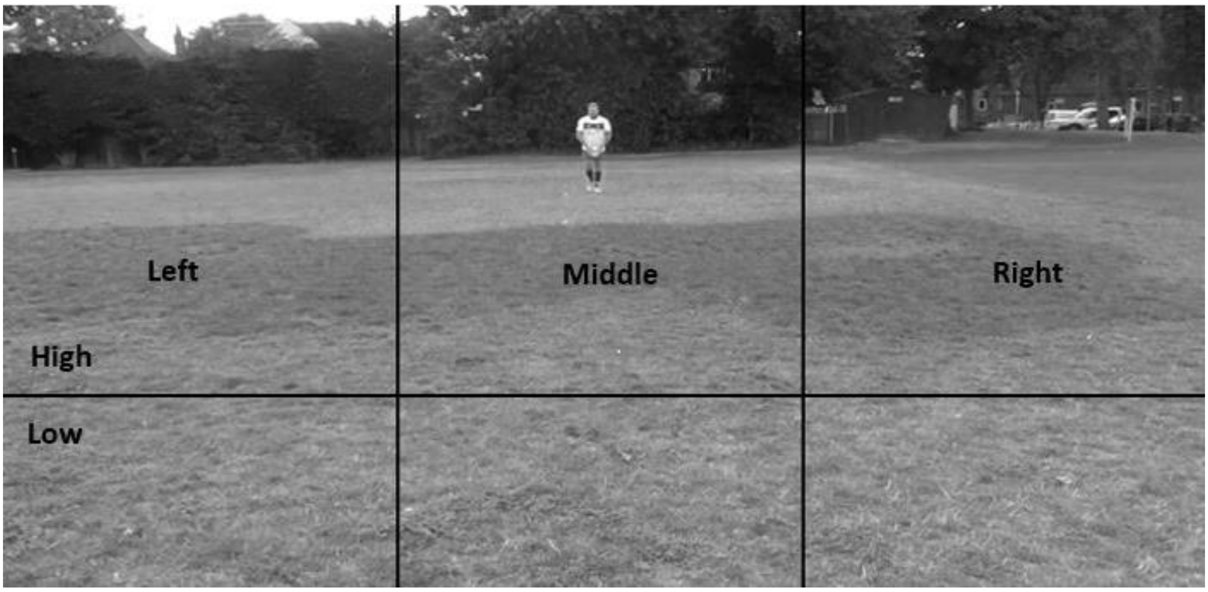

Figure 1. Occlusion video with horizontal and vertical definitions.

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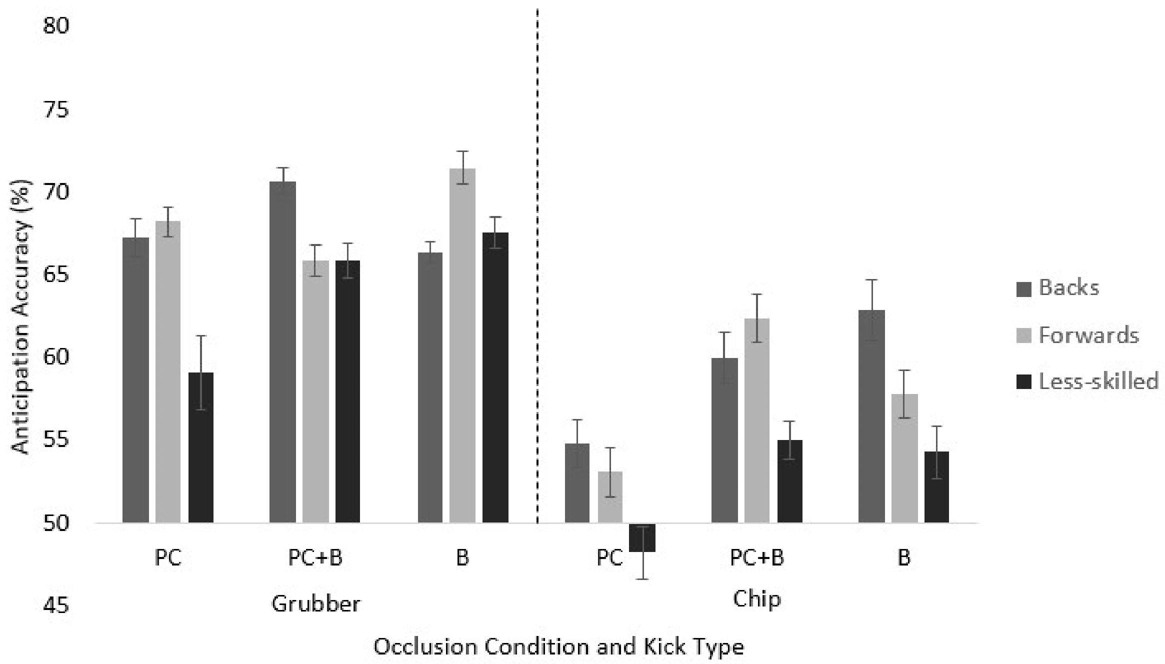

595 Figure 2. Mean vertical anticipation accuracy (+ SE) for grubber and chip kicks in each
596 occlusion condition for professional backs and professional forwards and less-skilled
597 participants. The x axis crosses at chance level (50%).

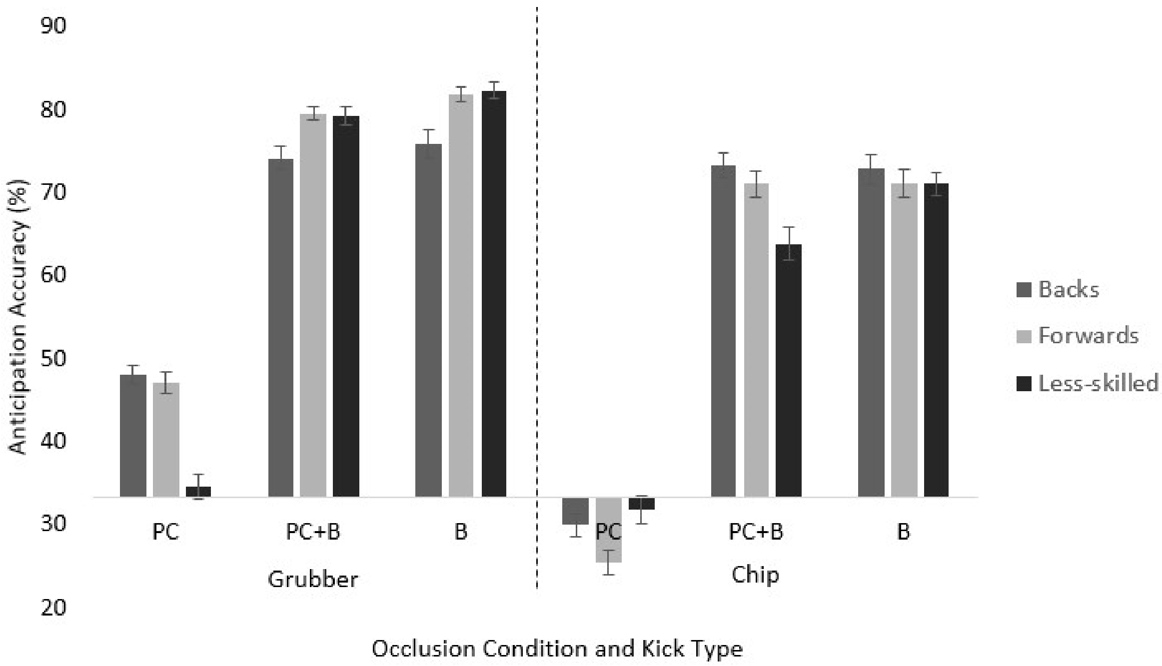

Figure 3. Mean horizontal anticipation accuracy (+ SE) for grubber and chip kicks in each occlusion condition for professional backs and professional forwards and less-skilled participants. The x axis crosses at chance level (33.33%).

Table 1.
Number of grubber and chip kicks in each possible outcome location.

	Grubber				**Chip**			
	Left	Middle	Right	Total	Left	Middle	Right	Total
High	11	7	3	21	13	8	0	21
Low	16	2	3	21	17	25	6	48
Total	27	9	6	42	30	33	6	69

Table 2.
Percentage response accuracy (mean ± SD) for skill-level, kick type, and occlusion condition.

	Vertical (chance level = 50%)						Horizontal (chance level = 33.33%)					
	Grubber			Chip			Grubber			Chip		
	PC	PC+B	B	PC	PC+B	B	PC	PC+B	B	PC	PC+B	B
Backs	67.3 ± 8.8	70. 7 ± 6.3	66.4 ± 5.1	54.8 ± 11.0	60.0 ± 11.4	62.9 ± 14.3	48.12 ± 8.1	74.2 ± 10.5	75.9 ± 12.8	30.0 ± 10.5	73.3 ± 11.6	72.9 ± 13.8
Forwards	68.24 ± 6.7	65.9 ± 7.0	71.5 ± 7.4	53.1 ± 11.2	62.4 ± 11.0	57.8 ± 10.8	47.1 ± 10.0	79.6 ± 6.3	81.9 ± 7.4	25.5 ± 10.9	71.1 ± 12.1	71.1 ± 12.8
Less-skilled	59.1 ± 17.4	65.9 ± 7.8	67.6 ± 7.3	48.2 ± 12.2	55.0 ± 8.7	54.3 ± 12.1	34.6 ± 10.8	79.4 ± 8.3	82.4 ± 7.4	31.8 ± 12.8	63.9 ± 14.6	71.1 ± 10.5

Postural cues only (PC); Postural cues and ball-flight (PC+B); Ball flight only (B)