Perceiving and Acting Upon Spaces in a VR Rugby Task: Expertise Effects in Affordance Detection and Task Achievement

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This study used a virtual, simulated 3 vs. 3 rugby task to investigate whether gaps opening in particular running channels promote different actions by the ball carrier player and whether an effect of rugby expertise is verified. We manipulated emergent gaps in three different locations: Gap 1 in the participant’s own running channel, Gap 2 in the first receiver’s running channel, and Gap 3 in the second receiver’s running channel. Recreational, intermediate, professional, and nonrugby players performed the task. They could (i) run with the ball, (ii) make a short pass, or (iii) make a long pass. All actions were digitally recorded. Results revealed that the emergence of gaps in the defensive line with respect to the participant’s own position significantly influenced action selection. Namely, “run” was most often the action performed in Gap 1, “short pass” in Gap 2, and “long pass” in Gap 3 trials. Furthermore, a strong positive relationship between expertise and task achievement was found.

Keywords: perception-action coupling, affordance, decision making, expertise, team sport, rugby union

To better understand successful performance in team sports one must consider the perception of action possibilities emerging from players’ interpersonal interactions. The aim of this study was to investigate which action possibilities are perceived and executed (from the perspective of the ball carrier) in a typical three-versus-three (3vs3) rugby scenario where the changing position of the defenders results in emerging gaps or “spaces” in different running channels of the defensive line. More specifically, we wanted to see how the location of an opening gap with respect to the ball carrier, influenced the action selection. Furthermore, we also wanted to see how action selection differed with levels of rugby expertise.
In rugby union, as in any team sport, game cooperation and competition for space co-occur throughout the game. For instance, the player who is the ball carrier is constantly looking for spaces in the defensive line through which he/she or a teammate can run so as to get nearer to the try line. In terms of action possibilities (or affordances, Gibson, 1979), the ball carrier can run, pass or kick the ball to gain some kind of territorial advantage. Affordances (Gibson, 1979) are a key concept for this study. They imply a mutual and reciprocal relationship between the individual and the environment in which he/she is acting and are taken with reference to the individual’s particular action capabilities (see Fajen, Riley, & Turvey, 2009, for a review in sport). As follows, decision making in sport can be regarded as a goal-directed process of acting on the affordances available in the performance environment (e.g., Araújo, Davids, & Hristovski, 2006).

Empirical research on the affordance of passing through apertures (Warren & Whang, 1987; Watson et al., 2011) has demonstrated that successful behavior is a matter of perceiving affordances in an attuned fashion (Fajen & Turvey, 2003). As stated by Fajen and Turvey (2003) “a narrow opening may afford passage by a small child, but not by a large adult; a narrower opening may afford passage by a cat but not by a small child” (p. 277). Likewise, for an attacker in rugby union, the reception of a ball may offer him/her the opportunity to run to score a try if a sufficient gap in the defensive line is perceived. Accordingly, successful decision behavior from this perspective rests on the ability to perceive which goal-directed actions are possible (Fajen & Turvey, 2003; Turvey, 1992).

Information is directly related to affordances, since to perceive an affordance is to perceive the information specifying it (Gibson, 1979). Players in team sports are surrounded by abundant sources of energy arrays that convey information that shapes decision making and action during goal-directed activity (Davids, 2009). As follows, the information that is available in changing spaces in the defensive line may be perceived by a ball carrier as offering two general action possibilities. The ball carrier either perceives it as passable and runs through the perceived defensive gap, or as not passable and kicks the ball or passes it on to a teammate. Actions may be thus regarded as categorical and the boundaries separating different categories may be defined by the player-environment fit (Fajen & Turvey, 2003) as scaled by his/her body and action capabilities (Araújo, Davids, Chow, & Passos, 2009; Turvey & Shaw, 1995). Manipulating task constraints and assessing how they influence the action performed have been regarded as providing information on how goal-directed processes of perception influence decision making, supporting the fit between players and performance environments. For instance, Hristovski and colleagues (Hristovski, Davids, Araújo & Button, 2006) in a study on boxing demonstrated how manipulated changes in the scaled distance to the target affected boxer punching action patterns.

The consistent successful behavior often demonstrated by experts illustrates the improved fit of the relation between the player and the performance environment (Araújo et al., 2009; Jacobs & Michaels, 2007), in terms of the adaptive and functional relationship they establish (Araújo & Davids, 2011; Araújo, Davids, & Serpa, 2005; Jacobs & Michaels, 2007). Expertise in team sports must therefore be considered in terms of the player–environment system (Turvey & Shaw, 1995) and should ideally be assessed by upholding natural perception–action interactions (e.g., Araújo et al., 2009). Perception–action reciprocity is present.
if performers’ actions bring about a change in the informational layout of the surrounding environment through the creation of optic flow. In turn, the detection of these informational changes shapes their ensuing actions. Immersive and interactive virtual reality (VR) environments, besides preserving this reciprocity, allows for the precise control of otherwise uncontrollable variables, such as the informational layout of the surrounding environment. In addition to the manipulation of the information presented to the observers, accurate recordings of ensuing behavioral responses can also be made. This type of technology ensures reproducibility between trials. This setting offers an exceptional context for manipulating task constraints while providing players and nonplayers with sport performance scenarios from an egocentric viewpoint (updated in real time) and guarantees perception–action coupling (for a review of VR advantages in sports performance research, see Bideau et al., 2010).

In light of the above, the present work has used this technology to look at a 3vs3 rugby union task in a virtual environment where realistic simulations of attackers versus defenders were reconstructed. The study had two main objectives. Firstly, to investigate how the affordance of opening gaps offers different action opportunities to players, independent of their level of expertise, and secondly, to show how rugby expertise influences action selection in terms of both affordance perception and task achievement.

Methods

Participants

Forty-six participants (n = 46) took part in this experiment and were divided into four groups: nonrugby players (n = 9; M_age = 26.63 years, SD = 2.97), recreational (n = 9, M_age = 26.00 years, SD = 7.35), intermediate (n = 16, M_age = 26.56 years, SD = 4.10) and professional (n = 12; M_age = 20.33 years, SD = 1.15). The study had full ethical approval and all participants gave informed written consent and filled in a questionnaire regarding their sports experience, specifically relating to competitive rugby engagement.

The criteria used to define the level of expertise were set according to the reported number of years of competitive rugby practice and current level of engagement in the activity. Accordingly, a nonrugby group included participants who were familiar with the elementary rules of rugby, but who had never played rugby before. The players in the recreational group had on average 5 years of competitive rugby experience (M = 5.44 years, SD = 4.66), with experience being limited to a lower regional level, and no international experience. Players in the intermediate group had on average 13 years rugby experience (M = 12.94 years, SD = 4.27), playing at both regional and national level, and at a superior league level. The professional group had on average 13 years rugby experience (M = 12.50 years, SD = 1.51) playing at both regional and top national level, with all players having some form of experience in international competition. It is important to note that they were full-time professional rugby players within the only professional national rugby team (Ulster Rugby, Northern Ireland) which competes in European competitions. All participants were not familiar with the specific virtual reality simulation used and all performed exactly the same tasks.
Task

The experimental task consisted of a virtual simulated 3vs3 rugby situation. Participants performed the task individually from the perspective of the ball carrier (attacking player) while carrying a real ball in their hands. Participants wore a head-mounted display unit (Cybermind Visette, 60 Hz, 45° diagonal field of view) with a control box mounted in a backpack also carried by the participants (Figure 1). A wireless Intersense head tracker (Intersense 900 MicroTrax 6-DOF tracker) was attached to the top of the head set and two wired hand trackers attached to a pair of rugby gloves allowed for the capture of both the position and orientation of the head and hands (sampling at 80 Hz) in the virtual environment. The position of the head tracker controlled the viewpoint in the virtual environment in real time with a latency of 4 ms between movement and visualization (virtual environment controlled and rendered using 3DVia Virtools 4.1). Movement in the real world directly mapped onto movement in the virtual space. That is to say a 1-m displacement in the real world corresponded to 1-m displacement in the virtual world. This spatial mapping gave participants the impression of being immersed in a standard rugby pitch (70 m × 144 m) inside a virtual stadium.

Participants could see three defenders in front of them (see Figure 1A) and two attacking teammates to either their right- or left-hand side depending on their position. Figure 1 — The immersive interactive virtual reality apparatus. The panel on the left shows a participant wearing the head mounted display (HMD) with attached head tracker along with the backpack that housed the control unit. The players also wore a pair of rugby gloves onto which two hand trackers were attached. Panel A illustrates what the players could see in front of them (i.e., the defensive line), and panel B shows what they could see if they turned their head to the left or the right, that is, the position of their teammates (first and second receivers).
preferred side for passing. If for example their preferred, or stronger side, was to the left, the teammates were aligned to their left and vice versa if their preferred passing side was on the right (see Figure 1B). The running motion of these virtual players (i.e., defenders and teammates) originated from motion capture (Qualisys oqus) of a real rugby player running in a straight line. This motion capture was then converted into an animation loop and imported into the virtual environment (Autodesk Motionbuilder and 3DS Max 2011), where it was used as a basis to animate all movements of the virtual characters. This meant that all virtual players were of identical build and height, and ran in a similar fashion. Virtual depictions of the participant’s hands were also visible in the virtual environment and corresponded to the real relative position and orientation of the hands with respect to the head in the real world. The participants held a real ball in their hands and this too was animated in the virtual environment. Both seeing their real hands virtually and feeling and seeing a ball in their hands helps heighten the sense of presence by combining both visual and haptic sensations of hand and ball movement.

During the task the line of three defenders ran toward the attackers. The participant was the ball carrier and was able to perform the task as if in the real rugby situation where the aim was to break the defensive line. In other words the attacking player was encouraged to choose the action (run, pass short or pass long) that would result in the ball being taken beyond the line of defenders while avoiding contact with the opposing players. To succeed, the ball carrier has to therefore identify the emerging space between the defenders and perform the appropriate action. The ball carrier can do this by running through the opening gap in his/her own channel, or passing the ball to one of the two teammates who could exploit an opening gap further along the defensive line. A pass made to the first teammate was classified as a short pass while a pass made to the second teammate was a long pass. Kicking was not allowed primarily for safety reasons and to force the players to exploit gaps in the defensive line rather than the space behind the defensive line.

Design and Procedure

In the 3vs3 virtual simulated task, the starting positions of the attackers (the ball-carrying participant, and his/her two teammates) and the three defenders all started in the same position. The distance between the ball carrier and the defensive line was 20 m. The defensive line moved forward at a speed of 10 m/s. Each dyad of attacker and marking defender was positioned in a corresponding running channel (see Figure 2). A trial ended when the defenders reached the attacking line. As the defenders ran toward the attackers, the running angle of one of the defenders would change so as to open a gap in a particular running channel. This opening gap between two defenders was manipulated to give rise to three different gap locations (see Figure 2). By changing the running angle, the defender would end up at an end position that was 1 m away from where he would have been if he had ran toward the attacking player in a straight line. The three different gaps that opened during the unfolding action were located in the participant’s own running channel (Gap 1), the first teammate’s running channel (Gap 2), and the second teammate’s running channel (Gap 3) (Figure 2). In addition, we also presented a “no gap” condition (neutral condition) where all defenders ran in a straight line toward the attackers (i.e., no gap opened in any of the running channels).
Before the experiment began, all players were given a period of familiarization. Participants were encouraged to walk around and become familiar with their virtual environment. They were also asked to practice throwing the real ball to their virtual teammates who they could see and hear calling for the ball in the virtual environment. Players performed five short passes and five long passes to their preferred side. This allowed the experimenter to differentiate the two types of pass for a particular participant.

During the main experiment, each participant was randomly presented with the four different gap conditions (three gaps and one control) a total of six times giving rise to 24 experimental trials. All of the players performed the experiment so that any pass made would be to their preferred side. This information was obtained

Figure 2 — Schematic representation of the different gap conditions. Each gap location is defined by varying the running angle of the defender in a specific running channel. Gap 1 (top left): located in the participant’s own running channel would afford the run action choice. Gap 2 (top right): located in the running channel of the first receiver would afford a short pass to this teammate. Gap 3 (bottom left): located in the running channel of the second receiver would afford a long pass to this teammate. For the No Gap condition (bottom right), all the defenders’ ran in a straight line with no gap opening in any of the running channels.
before the experiment began. Actions performed by the participants in each of the trials was identified by the experimenter and corroborated a posteriori by the participant as run, short pass or long pass. Importantly, it was made explicit that this was merely a procedure to validate the identified action and did not provide any feedback on the accuracy of their action choice. The accuracy of the pass was not considered, as it was not within the remit of this study.

It is important to note that the design of this experiment was based on a previous pilot field study performed with professional players from the Ulster rugby team. Although the players in the pilot study are from the same professional squad of players, they did not participate in the main experiment. In the pilot study a 3vs3 rugby task was performed wherein one defender was instructed (unknown to the attackers) to change his running angle so that a gap would “open” between players. The actions chosen by the attackers based on the running angles of the defenders informed the parameters selected for this study. The “backs” coach of this professional team was also asked what a ball carrier would “typically” do when confronted with gaps opening in different running channels. The illustration in Figure 2 shows that a gap opening in a participant’s own running channel (Gap 1) would offer a running action, a gap opening in the first receiver’s running channel (Gap 2) would afford a pass from the ball carrier to that teammate (i.e., a short pass) and finally a gap opening in the second receiver’s running channel (Gap 3) would afford a pass from the ball carrier to that teammate (i.e., a long pass).

### Results

#### Action Performed

To investigate the relationship between expertise (Group), the location of the opening gaps plus the no gap condition (Gap), and the action performed a $4 \times 4$ (Group $\times$ Gap), multivariate analysis of variance (MANOVA) was conducted with each of the three classified actions (run, short pass, and long pass) as dependent variables. Statistics used to test significance of main effects and interactions were Wilks’s lambda (LRATIO) and Bonferroni post hoc tests. Statistical significance was set at $p < .05$ level.

**Gap Location Effects in the Action Performed.** The location of the gaps was found to significantly influence the action that was performed (LRATIO = 38.438, $p < .001$, $\eta^2_p = .408$) (see Table 1). This was manifested in the running action being significantly more frequent for Gap 1 ($M = 87.68$, $SD = 25.20$) when compared with No Gap ($M = 31.88$, $SD = 29.78$), Gap 2 ($M = 28.99$, $SD = 27.09$), or Gap 3 ($M = 28.26$, $SD = 27.41$) conditions ($p < .001$; see Figure 3A).

As regards to the short pass action, this was significantly more frequent in Gap 2 ($M = 64.49$, $SD = 31.94$) when compared with the No Gap ($M = 35.14$, $SD = 23.63$), Gap 3 ($M = 25.72$, $SD = 27.38$), or Gap 1 ($M = 2.54$, $SD = 7.83$) conditions ($p < .001$; see Figure 3A).

Finally, the long pass action was significantly more frequent in Gap 3 ($M = 46.01$, $SD = 35.86$) when compared with No Gap ($M = 32.97$, $SD = 24.97$), Gap 1 ($M = 9.78$, $SD = 21.82$), and Gap 2 ($M = 6.52$, $SD = 13.37$) conditions ($p < .001$; see Figure 3A).
Expertise Effects on the Action Performed. A significant main effect for Group (LRATIO = 2.573, \( p = .019 \), \( \eta_p^2 = .044 \)) was found but only for the running action (see Table 1). The post hoc tests (see Figure 3B) indicated that the running action was significantly more frequent in the recreational group (\( M = 56.02, SD = 35.89 \)) compared with the professional group (\( M = 34.72, SD = 40.22 \)) (\( p = .001 \)). Although the recreational group was higher than the nonrugby (\( M = 48.15, SD = 32.56 \)) and intermediate (\( M = 42.45, SD = 36.36 \)) groups, these differences were not significant (\( p > .05 \)).

For the short pass, professional players (\( M = 36.46, SD = 37.13 \)), nonrugby players (\( M = 30.09, SD = 24.18 \)) and intermediate players (\( M = 33.59, SD = 34.82 \))
Table 1  Effects of a Multivariate Analysis of Variance (MANOVA)

<table>
<thead>
<tr>
<th>Effect</th>
<th>Run</th>
<th></th>
<th></th>
<th>Short Pass</th>
<th></th>
<th></th>
<th>Long Pass</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>F(3,168)</td>
<td>p</td>
<td>η²p</td>
<td>F(3,168)</td>
<td>p</td>
<td>η²p</td>
<td>F(3,168)</td>
<td>p</td>
<td>η²p</td>
</tr>
<tr>
<td>Gap</td>
<td>50.196</td>
<td>&lt;.001**</td>
<td>.473</td>
<td>50.021</td>
<td>&lt;.001**</td>
<td>.472</td>
<td>22.629</td>
<td>&lt;.001*</td>
<td>.288</td>
</tr>
<tr>
<td>Group</td>
<td>5.162</td>
<td>.002*</td>
<td>.084</td>
<td>2.051</td>
<td>.109</td>
<td>.035</td>
<td>1.332</td>
<td>.266</td>
<td>.023</td>
</tr>
<tr>
<td>Group × Gap</td>
<td>2.669</td>
<td>.006*</td>
<td>.125</td>
<td>5.053</td>
<td>.001*</td>
<td>.213</td>
<td>4.217</td>
<td>.001*</td>
<td>.184</td>
</tr>
</tbody>
</table>

*Note. *p < .05, **p < .001.*
performed this action more frequently than recreational players ($M = 25.00, SD = 30.99$), though this was not found to be significant.

The long pass action was more frequent among the professional players ($M = 28.82, SD = 34.85$) compared with the nonrugby ($M = 21.76, SD = 23.17$), the intermediate ($M = 23.82, SD = 31.83$) or the recreational group ($M = 18.98, SD = 25.56$). However, these differences were not found to be significant.

Although each gap condition made up a quarter of the total trials performed, the action performed was not equally distributed across groups. It is interesting to note that frequencies of run, short pass, or long pass actions performed by the professional group across all experimental conditions were closest to the expected experimental ratio (i.e., about 33.33%).

**Gap and Expertise Interaction Effects on the Action Performed.** A significant Gap $\times$ Group interaction was also found for the three actions performed (see Table 1). For Gap 1 (Figure 4A), the groups performed the running action at a similar frequency (all $p > .05$). However, for Gap 2 (Figure 4B), the frequency of short passes was significantly greater for the professional group than for the recreational ($p = .008$) and the nonrugby ($p < .001$) groups but not for the intermediate group. The nonrugby group differed significantly ($p < .001$) from all the other groups except for the recreational group. For the rugby players, the recreational and intermediate groups differed significantly ($p = .023$), but not the intermediate and professional groups ($p > .05$). For Gap 3 (Figure 4C), the frequency of long passes for the professional group was significantly greater than for the recreational ($p = .001$) and the nonrugby ($p < .001$) groups but not for the intermediate group ($p > .05$). Although the nonrugby group differed significantly from the intermediate group ($p = .003$), no significant differences were found between the recreational and the nonrugby and intermediate groups ($p > .05$).

For the no-gap condition (Figure 4D), no particular action was obvious, and only the frequency of the running action differed significantly between groups. This action was performed less often by the professional group compared with the recreational ($p = .070$) or the nonrugby playing group ($p = .027$). For both short and long passes, no significant differences were found between the groups ($p > .05$).

**Task Achievement**

The analysis presented above verifies that the frequency of the expected action for the different gap conditions was significantly higher than all the other possible actions (cf. the pilot study and head coach testimony). However, to examine the effect of progressive rugby expertise in terms of task achievement, we considered a particular expected action as the action afforded by the location of an opening gap (i.e., Gap 1, a running action; Gap 2, a short pass; Gap 3, a long pass) and looked at its frequency as a measure of task achievement. It is important to note that, as expected, in the No Gap condition no particular action possibility was deemed correct as the distance between defenders did not change during the course of the action. As this condition was simply a control condition, it was not included in this analysis. A $4$ (Group) $\times 3$ (Gap) univariate ANOVA was thus conducted with task achievement as the dependent variable. Bonferroni post hoc tests were used to test for significant differences between conditions. Statistical significance was set at $p < .05$ level.
Figure 4 — The panels show each defensive gap location broken down as a function of the three possible actions (run, short pass or long pass). Panel A: Gap 1 corresponds to a gap opening in the ball carrier’s own running channel; Panel B: Gap 2 corresponds to a gap opening in the first receiver’s running channel; Panel C: Gap 3 corresponds to a gap opening in the second receiver’s running channel; Panel D: No Gap corresponds to the condition where no gap opens. *p < .05. **p < .001.
**Gap Effects on Task Achievement.** A gap main effect was found for task achievement, $F(2, 126) = 28.253$, $p < .001$, $\eta^2_p = .310$. Achievement in Gap 1 ($M = 87.68, SD = 25.20$) was significantly greater than in Gap 2 ($M = 64.49, SD = 31.94$) and in Gap 3 ($M = 46.01, SD = 35.86$) ($p < .001$). Performance in Gap 2 was also significantly greater than Gap 3 ($p = .008$) (see Figure 5A).

![Figure 5](image)

**Figure 5** — A: Gap location main effects. The percentage of task achievement (assumed as the frequency of the expected action) broken down as a function of the opening gap locations. Gap 1 corresponds to gaps opening in ball carrier’s own running channel; Gap 2 corresponds to gaps opening in the first receiver’s running channel; Gap 3 corresponds to gaps opening in the second receiver’s running channel. B: Group main effects. Percentage of task achievement (assumed as the frequency of the expected action possibility) broken down as a function of each group of participants: nonrugby players, recreational, intermediate and professional rugby players.
Expertise Effects on Task Achievement. Also observed was a significant main effect of Group on task achievement, $F(3,126) = 14.964, p < .001, \eta^2_p = .263$, with the nonrugby group ($M = 39.51, SD = 34.01$) performing significantly worse than the intermediate ($M = 73.61, SD = 31.67$) ($p < .001$) and the professional ($M = 82.41, SD = 25.18$) ($p < .001$) groups. Although lower than the recreational group ($M = 57.41, SD = 39.04$), the nonrugby group was not significantly lower ($p > .05$). The recreational group had significantly lower performance than the professional group ($p = .003$). No significant differences were found between the recreational and the intermediate groups, or between the intermediate and the professional groups ($p > .05$) (see Figure 5B).

Gap and Expertise Interaction Effects on Task Achievement. There was no significant Gap $\times$ Group interaction, $F(6, 126) = 1.11153, p = .336, \eta^2_p = .052$, on task achievement.

Discussion

In this study we examined how “free” spaces (i.e., opening gaps) located in specific running channels influence the perception of action possibilities and ultimately the actions carried out. Furthermore, we investigated whether this putative gap modulation of the players’ actions might be related to differences between levels of rugby expertise. To accomplish this, we used an interactive 3vs3 VR rugby task.

Different Gap Locations Offer Different Actions Independently of Participants’ Expertise Level

Depending on their locations, the manipulated defensive gaps shaped participants’ behavior. Overall when facing a gap opening in (i) their own running channel, (ii) in their first teammate’s running channel or (iii) in their second teammate’s running channel, participants correspondingly often (a) ran (in their own channel), (b) passed short to their first teammate, or (c) passed long to their second teammate. The fact that nonrugby players and players alike perform a particular action suggests that the action most often selected for each gap location was the affordance that was best aligned with the task goals. Interestingly, for the no gap condition (where no gap was opening) no particular action occurred significantly more often than any other. This may be considered as a demonstration of direct perception of action possibilities in the game of rugby union as recently pointed out by Craig and Watson (2011). According to these authors it is common to observe a player receiving the ball and requesting the teammates to perform a preplanned move, such as to pass the ball wide. However, during the unfolding action it may be that an affordance is perceived, such as a gap opening in the nearest teammate’s running channel, which creates a new opportunity for a short pass action, which overrides the preplanned move.

Significant interactions were also found between gap location and expertise (i.e., group of participants) for the three actions performed. This distinction in the action carried out for the different gaps was more evident in the group of professional players. From an ecological perspective, perception–action coupling rests on the detection and use of information (Gibson, 1979). These performance variations, resulting from the experimental manipulation of gap location, suggest
that information available in these manipulations is shaping the emerging actions (Beek, Dessing, Peper, & Bullock, 2003). None of the participants were especially familiar with the VR setting, so the differences observed here may be an indication of a greater functional fit between those participants who were already considered as “experts” in this rugby type situation. That is, professional players were better able to distinguish the information specifying the affordance in each of the varying gap conditions.

Rugby Expertise Effects in Selecting the Action for Task Achievement

In keeping with the above, the different manipulated defensive gap locations offer particular actions. The frequency of a given action was thus regarded as a measure of task achievement. For the overall groups of participants, achievement was best when the gaps opened in the participant’s own running channel, not as good when in the first teammate’s channel and least good in the case of the second teammate’s running channel. These results suggest that it is easier to perceive an affordance for oneself than for others. The gaps emerging in different running channels also mean differences in terms of optical angles of each of those gaps from the viewpoint of the ball carrier participant. Although in each location the size of the manipulated gap is equal, in terms of optical angles from the viewpoint of the ball carrier they are very different (e.g., Gap 3 corresponds to the narrowest optical angle). Achievement differences or the difficulty to perceive the affordance for others—such as a gap opening further away through which a teammate could break the defensive line if the ball was passed to him—may be due to these differences in optical angles specifying the action afforded by those opening gaps. Besides, according to Smith and Pepping (2010), information specifying some affordances may be faster or easier to detect than others. This might also be the case of the current study. To further test this assumption, future research must address a description of these angles and how their change in space and time affects perception of affordance and achievement in this rugby subphase of the game.

For the overall gap conditions, rugby players were more successful than nonrugby players. Although they did not perform as well as the rugby players, nonrugby players still perceived similar gap affordances as rugby players. Within the different groups of rugby players, the greater the experience of the players, the greater the achievement in the task. This positive relationship between expertise and performance on this task suggests that the location characteristics of the dynamic opening gaps influenced the ball carrier’s decision-making behavior.

These findings are consistent with the argument of expertise resting on the improved fit of the relationship between the performer and their environment (e.g., Araújo et al., 2009; Jacobs & Michaels, 2007; Turvey & Shaw, 1995). Given that the goal of the task was to break the defensive line while avoiding contact, performance of the professional group was more expert-like given its “contextualized functional value” (Araújo, 2007).

Starkes and Ericsson (2003) reported higher variability in athlete performance in expert/novice studies compared with observations of expert decision making in
actual performance contexts where they consistently show high performance. This higher level of performance in situ was also shown in this experimental interactive and immersive VR rugby task. Moreover, expertise in sport is not often manifested solely in the ability to make perceptual judgments, but rather when perception is coupled to action (Craig et al., 2009; Farrow & Abernethy, 2003). Here, as in other studies (Brault et al., 2012; Dessing & Craig, 2010), we show expertise effects when perception and action are coupled. Moreover, at the level of perception and action these findings are consistent with the view that adaptive behavior emerges from the environment–agent interaction under various physical and informational constraints (Warren, 2006).

Overall, the findings convey the action fidelity characteristics of this task and outline how this technology has great potential to study decision making in sport (Bideau et al., 2010). According to Stoffregen and colleagues (2003), this characteristic is demonstrated when there is a transfer from the simulator to the simulated system, that is, to the actual performance context (Pinder, Davids, Renshaw, & Araújo, 2011). Decisional behavior observed in participants in this experiment may be assumed as mirroring that of the actual subphase of the rugby game performance environment. Participants in this experiment acted only with respect to the information made available by the dynamics of the movements of the defenders. If emergent action is like that expected in the real rugby situation, then this information is useful for the regulation of decisional behavior in the actual performance context. One of this study’s main advantages lies in the fact that experimentally controlled information that could not be normally controlled in situ can be controlled in the virtual environment, allowing for an in depth examination of how information shapes action. Moreover, it allows us to overcome some difficulties that are found in situ, such as the impracticality of examining rugby-specific decision making of nonrugby players given, for instance, the physical contact allowed in the game (Araújo et al., 2005).

In summary, this study sheds light on our understanding of decisional behavior in a dynamic 3vs3 task where free spaces must be perceived as well as carried out the appropriate action that allows performance goals to be achieved. By embracing perception–action coupling, while maintaining experimental control and manipulation over the information made available, this study demonstrates how even those without rugby experience can pick up the information specifying the opening of a gap and use it to shape their decision-making behavior. Furthermore, by involving participants with different levels of expertise, it was possible to demonstrate the effect of rugby expertise on perceiving and acting upon game relevant affordances.

Acknowledgments

The first author is supported by the project grant SFRH/BD/36480/2007 (Foundation for Science and Technology, Portugal). This research was also supported by a European Research Council StIG TEMPUS_G 210007 awarded to the last author. Authors wish to thank Gareth Watson for assistance with the pilot experiment setup and early comments on the designing of the experiment. Thanks also to Caroline, Claire, Drew, and Elena for assistance with data collection. Finally, thanks to Ulster Rugby players and coaches and to the participants who volunteered.
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Manuscript submitted: October 2, 2011

Revision accepted: February 4, 2012