Posture-related affordances guide attacks in basketball

Pedro T. Esteves\textsuperscript{a,*}, Rita F. de Oliveira\textsuperscript{b,c}, Duarte Araújo\textsuperscript{a}

\textsuperscript{a} Faculty of Human Kinetics, Technical University of Lisbon, Estrada da Costa, 1499-002 Cruz Quebrada—Dafundo, Portugal
\textsuperscript{b} Department of Psychology, Royal Holloway, University of London, Egham TW20 0EX, United Kingdom
\textsuperscript{c} Institute of Psychology, German Sport University Cologne, Am Sportpark Müngersdorf 6, 50933 Cologne, Germany

\textbf{ARTICLE INFO}

Article history:
Received 2 December 2010
Received in revised form 17 May 2011
Accepted 5 June 2011
Available online 26 June 2011

\textbf{Keywords:}
Decision making
Perception
Action
Visual information
Sport psychology
Training

\textbf{ABSTRACT}

\textbf{Objectives:} The purpose of this study was to investigate the decision made by the attacker to drive to the left or right of the defender.

\textbf{Method:} Participants were 32 novice and intermediate basketball players who were assigned the role of attacker or defender in a one-on-one subphase. We manipulated the defender’s posture and measured both the postures of defenders and attackers and the ensuing decision on drive direction.

\textbf{Results:} As hypothesized, the posture of defenders guided the decision behavior of the attacker. Both novice and intermediate attackers made the same affordance-based decision by driving to the side of the defender’s most advanced foot, but only when the distance between attacker and defender was small. Moreover, novice attackers conveyed postural information regarding their upcoming drive direction while intermediate attackers were better able to conceal this information.

\textbf{Conclusions:} These results lend further support to the notion of information-based control of interpersonal actions in sport contexts.

Human adaptive behavior involves coordination between an individual and his or her environment (Gibson, 1979; Warren, 2006). A well-established field of research focused on interpersonal coordination (e.g., Marsh, Richardson, Baron, & Schmidt, 2006; Schmidt, Carello, & Turvey, 1990; Schmidt, O’Brien, & Sysko, 1999; Schmidt & Turvey, 1994) has demonstrated that individuals’ actions tend to be unintentionally synchronized with others. This seminal work has been extended to sport settings where numerous studies have been conducted (e.g., Araújo, Davids, Bennett, Button, & Chapman, 2004; Araújo, Davids, & Hristovski, 2006). It has been shown that decision behavior during sport interactions is shaped by a multiplicity of constraints, such as distance between players and players’ height (Cordovil et al., 2009).

However, the study of interpersonal coordination has never really delved into the study of what information sources guide action (Warren, 2006).

The concern about how information influences action has a long tradition in sport psychology (Williams, Davids, & Williams, 1999), with a particular emphasis in basketball (de Oliveira, Huys, Oudejans, van de Langenberg, & Beek, 2007; de Oliveira, Oudejans, & Beek, 2006, 2008, 2009). It has been argued that athletes identify kinematic information of their opponents, typically measured by head-mounted eye-tracking devices that follow the gaze of athletes watching films of sport actions (Williams, 2002; Williams et al., 1999). For instance, Savelsbergh, Williams, van der Kamp, and Ward (2002) found that goalkeepers detected information related to the trunk, hip, support leg, and kicking leg of the penalty taker. However, knowing what information source is perceived says little about how it is used to achieve task goals. Moreover, visual perception is used differently when it guides action vs. when it underpins a verbal judgment (Dicks, Button, & Davids, 2010; van der Kamp, Rivas, van Doorn, & Savelsbergh, 2008). For example, van der Kamp and Masters (2008) reported that even just the posture of a goalkeeper, projected on a screen, influences penalty-taking accuracy in handball. Nevertheless, these experimental tasks present methodological limitations regarding the visual perspective of the recorded actions and its bidimensionality, along with the impossibility of the individual interacting with the environment to perceive it better (Araújo, Davids, & Passos, 2007; Williams et al., 1999). Passive perception and decision making, typical of classic experimental designs, may be misleading when studying dynamic sports performance (de Oliveira et al., 2009).

According to Gibsonian theorizing (e.g., Gibson, 1979), ecological decision behavior is typically based on a continuous and active process of exploration and selection of relevant information to
support action. Functional behavior depends on the detection of action possibilities, or affordances (Gibson, 1979), specified in patterns of stimulus energy within the environment, in relation to the action capabilities of an individual. Affordances inform the individual about its ongoing relation with the environment (Fajen, Riley, & Turvey, 2009), which permits the selection of a course of action and also the prospective control of the chosen mode of action (Turvey, 1992). Past research has shown that observers can perceive affordances of another person by detecting kinematic information (Mark, 2007). However, the study of affordances in dynamical settings, like team ball sports, has received less research attention (Fajen et al., 2009).

In basketball, attackers and defenders must be attentive to the ever-changing opportunities for action. When an attacker dribbles past a defender (in a one-on-one subphase) it is called a drive. The success of the drive depends on choosing the moment and direction that will enable the attacker to get closer to the basket than the direct defender can. To overcome the opponent, the attacker has two action possibilities (i.e., affordances): a drive to the right or a drive to the left. Basketball coaches suggest that foot positioning of the defender may influence this decision. When the defender moves one foot closer to the attacker it becomes more difficult for the attacker to drive to that side (Krause, Meyer, & Meyer, 2008). If the attacker succeeds to drive to that side, however, the defender may take longer to recover the defensive position between the attacker and the basket. So, it is mostly the motion-related information (e.g., posture) readily available to both attacker and defender that informs the players' interactions ( Araújo et al., 2004; see also Reed, 1982). To our knowledge, little is known about what information variables influence the direction of drive of the attacker and how they are used in a one-on-one subphase of basketball.

In this study we analyzed the relationship between the posture of the defender and the drive direction of the attacker, in a one-on-one subphase of basketball. Specifically, we examined the influence of the defender's foot positioning on the choice of drive direction of the attacker at different levels of expertise. We also studied at what distance between attacker and defender postural information disclosed the upcoming actions of the attacker. Our hypothesis was that independent of the expertise level, the attacker would preferentially drive to the side of the defender's more advanced foot, as doing so offers a more functional solution for the attacker to pass the defender. Hence, by manipulating the defender's posture we expected to observe commensurate changes in the drive direction chosen by the attacker. On the basis of previous literature, however, we also expected this posture-related information to guide the drive only when the distance between attacker and defender was small. We also expected that compared with that of novices, the posture of more experienced attackers would be less informative about their upcoming direction of drive.

Method

Participants

We started by recruiting a cohort of 32 participants who were either novice ($n = 16$) or intermediate ($n = 16$) male basketball players. Thereafter, we formed 11 defender–attacker dyads in the novice group and 14 defender–attacker dyads in the intermediate group (see Table 1). The novice group was defined as having less than 8 years of structured practice and less than 2 years of competitive experience in basketball. (Our criteria meant that 13-year-old participants with 7 years of basketball experience were still considered novices.) The intermediate group was defined as having 8 or more years of structured practice and 2 or more years of competitive experience in the four highest leagues in Germany. On t-tests, the groups were significantly different on experience, $t(1, 23) = -5.40, p < .01$, and dribbling skills, $t(1, 23) = -2.75, p < .05$ (see Design and Procedure). These data reveal that attackers and defenders were well paired according to their experience and expertise level.

The nature of the experiment meant that the defender in the dyad was a confederate whereas the attacker was naïve. Therefore, in forming the dyads (1) some participants played the attacker (naïve) and were subsequently invited to play the defender (confederate) to another naïve participant, and (2) some participants were invited to play the defender to more than one attacker; (3) the defender and attacker in a dyad were of the same expertise group. The local ethics committee approved the experiment. Each participant gave his written informed consent before the experiment.

Experimental setup

The experimental setup consisted of a standard basketball backboard and rim placed in a basketball gym with official dimensions and line markings (International Basketball Federation, 2010). Two digital video cameras were placed outside the basketball field on either side of the setup, at a height of 3 m and angled downward at approximately 45°. These cameras recorded at 50 Hz the 14 × 15 m area where the trials took place. The starting position for the defender was the middle of the 3-point line, and for the attacker it was a line marked on the floor 3 m in front of the defender (Fig. 1).

Task

The task was for the attacker to dribble past the defender and shoot at the basket (from the painted area) within 10 s. This task is representative of 80% of the scoring situations that occur in a high-level basketball match (Vera et al., 2008). The defenders were instructed to hinder the attack by keeping themselves between the basket and the attacker (i.e., basket–attacker alignment). Importantly, defenders were also instructed to maintain (as much as possible during the trial) one of three prescribed postures: neutral, left, or right. Whereas in the neutral posture defenders should have the feet parallel to each other, the left and right postures prescribed the foot that should remain advanced in relation to the basket–attacker alignment. Two defenders took turns in the trials. The experimental task began with a bounce-pass from the defender to the attacker. Both attacker and defender were allowed to move freely in the half-court as long as they complied with the rules of basketball. Each trial ended when the ball was stolen or blocked by the defender, shot by the attacker, or when the time limit of 10 s was reached.

Design and procedure

Each participant performed four blocks of 18 trials for a total of 72 trials. There were three posture conditions for the defender: neutral, left, and right. The two defenders and three posture conditions were randomized with the proviso that neither was repeated in more than three consecutive trials. Initially participants filled out a questionnaire regarding their date of birth, weight, height, handedness specific to dribbling, time of practice, competitive level, and role in the team (all self-reported). After a free warm up of about 10 min, participants performed a skill test, which consisted of dribbling as many figure-eight sequences around their legs as possible within 30 s (Oliveira, Tina, & Faial, 2010). Two digital video cameras were placed outside the basketball field on either side of the setup, at a height of 3 m and angled downward at approximately 45°. These cameras recorded at 50 Hz the 14 × 15 m area where the trials took place. The starting position for the defender was the middle of the 3-point line, and for the attacker it was a line marked on the floor 3 m in front of the defender (Fig. 1).

Task

The task was for the attacker to dribble past the defender and shoot at the basket (from the painted area) within 10 s. This task is representative of 80% of the scoring situations that occur in a high-level basketball match (Vera et al., 2008). The defenders were instructed to hinder the attack by keeping themselves between the basket and the attacker (i.e., basket–attacker alignment). Importantly, defenders were also instructed to maintain (as much as possible during the trial) one of three prescribed postures: neutral, left, or right. Whereas in the neutral posture defenders should have the feet parallel to each other, the left and right postures prescribed the foot that should remain advanced in relation to the basket–attacker alignment. Two defenders took turns in the trials. The experimental task began with a bounce-pass from the defender to the attacker. Both attacker and defender were allowed to move freely in the half-court as long as they complied with the rules of basketball. Each trial ended when the ball was stolen or blocked by the defender, shot by the attacker, or when the time limit of 10 s was reached.

Design and procedure

Each participant performed four blocks of 18 trials for a total of 72 trials. There were three posture conditions for the defender: neutral, left, and right. The two defenders and three posture conditions were randomized with the proviso that neither was repeated in more than three consecutive trials. Initially participants filled out a questionnaire regarding their date of birth, weight, height, handedness specific to dribbling, time of practice, competitive level, and role in the team (all self-reported). After a free warm up of about 10 min, participants performed a skill test, which consisted of dribbling as many figure-eight sequences around their legs as possible within 30 s (Oliveira, Tina, & Faial, 2010).
Fig. 1. Experimental setup on a basketball half-court. The one-on-one situation started in the middle of the 3-point line with the defender (white shirt) and attacker (black shirt) facing each other. Standing near the table with drinks and snacks is the second defender who took turns defending on different trials. Two experimenters sat at another table and signaled the postures to the defender, imperceptible to the attacker, and recorded the result of the one-on-one for each trial.

Table 1
Biographical measures of the participants in each dyad who played the defender (D) and the attacker (A) in the intermediate and novice groups.

<table>
<thead>
<tr>
<th>Participant ID</th>
<th>Age (in years)</th>
<th>Weight (in kg)</th>
<th>Height (in cm)</th>
<th>Experience (in years)</th>
<th>League (0–6)</th>
<th>Dribbling skills (no sequences)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>D</td>
<td>A</td>
<td>D</td>
<td>A</td>
<td>D</td>
<td>A</td>
</tr>
<tr>
<td>Intermediate group (14 attackers, 16 defenders)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>36</td>
<td>92</td>
<td>86</td>
<td>194</td>
<td>186</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>31</td>
<td>80</td>
<td>92</td>
<td>180</td>
<td>194</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>31</td>
<td>86</td>
<td>80</td>
<td>186</td>
<td>180</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>26</td>
<td>73</td>
<td>86</td>
<td>185</td>
<td>186</td>
</tr>
<tr>
<td>5</td>
<td>27</td>
<td>27</td>
<td>86</td>
<td>87</td>
<td>183</td>
<td>190</td>
</tr>
<tr>
<td>6</td>
<td>27</td>
<td>29</td>
<td>92.5</td>
<td>87</td>
<td>191</td>
<td>190</td>
</tr>
<tr>
<td>7</td>
<td>27</td>
<td>27</td>
<td>74</td>
<td>87</td>
<td>181</td>
<td>190</td>
</tr>
<tr>
<td>8</td>
<td>15</td>
<td>24</td>
<td>88</td>
<td>108</td>
<td>197</td>
<td>180</td>
</tr>
<tr>
<td>9</td>
<td>15</td>
<td>38</td>
<td>75</td>
<td>108</td>
<td>183</td>
<td>180</td>
</tr>
<tr>
<td>10</td>
<td>8</td>
<td>22</td>
<td>71</td>
<td>88</td>
<td>179</td>
<td>197</td>
</tr>
<tr>
<td>11</td>
<td>8</td>
<td>20</td>
<td>83</td>
<td>88</td>
<td>189</td>
<td>197</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
<td>28</td>
<td>70</td>
<td>86</td>
<td>178</td>
<td>183</td>
</tr>
<tr>
<td>13</td>
<td>8</td>
<td>27</td>
<td>82</td>
<td>88</td>
<td>178</td>
<td>197</td>
</tr>
<tr>
<td>14</td>
<td>16</td>
<td>20</td>
<td>80</td>
<td>76</td>
<td>182</td>
<td>180</td>
</tr>
<tr>
<td>15</td>
<td>n.a.</td>
<td>15</td>
<td>30</td>
<td>108</td>
<td>n.a.</td>
<td>180</td>
</tr>
<tr>
<td>16</td>
<td>n.a.</td>
<td>16</td>
<td>23</td>
<td>76</td>
<td>n.a.</td>
<td>180</td>
</tr>
<tr>
<td>Novice group (11 attackers, 16 defenders)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>21</td>
<td>17</td>
<td>17</td>
<td>96</td>
<td>198</td>
<td>197</td>
</tr>
<tr>
<td>18</td>
<td>14</td>
<td>15</td>
<td>17</td>
<td>78</td>
<td>179</td>
<td>198</td>
</tr>
<tr>
<td>19</td>
<td>29</td>
<td>17</td>
<td>27</td>
<td>84</td>
<td>193</td>
<td>183</td>
</tr>
<tr>
<td>20</td>
<td>17</td>
<td>17</td>
<td>70</td>
<td>96</td>
<td>183</td>
<td>198</td>
</tr>
<tr>
<td>21</td>
<td>19</td>
<td>17</td>
<td>92</td>
<td>84</td>
<td>197</td>
<td>193</td>
</tr>
<tr>
<td>22</td>
<td>29</td>
<td>14</td>
<td>27</td>
<td>62</td>
<td>167</td>
<td>183</td>
</tr>
<tr>
<td>23</td>
<td>32</td>
<td>14</td>
<td>22</td>
<td>56</td>
<td>171</td>
<td>165</td>
</tr>
<tr>
<td>24</td>
<td>32</td>
<td>14</td>
<td>22</td>
<td>62</td>
<td>180</td>
<td>165</td>
</tr>
<tr>
<td>25</td>
<td>4</td>
<td>21</td>
<td>23</td>
<td>67</td>
<td>181</td>
<td>185</td>
</tr>
<tr>
<td>26</td>
<td>4</td>
<td>13</td>
<td>23</td>
<td>62</td>
<td>182</td>
<td>185</td>
</tr>
<tr>
<td>27</td>
<td>27</td>
<td>26</td>
<td>90</td>
<td>85</td>
<td>180</td>
<td>183</td>
</tr>
<tr>
<td>28</td>
<td>n.a.</td>
<td>28</td>
<td>27</td>
<td>87</td>
<td>n.a.</td>
<td>190</td>
</tr>
<tr>
<td>29</td>
<td>n.a.</td>
<td>29</td>
<td>27</td>
<td>85</td>
<td>n.a.</td>
<td>183</td>
</tr>
<tr>
<td>30</td>
<td>n.a.</td>
<td>30</td>
<td>15</td>
<td>90</td>
<td>n.a.</td>
<td>194</td>
</tr>
<tr>
<td>31</td>
<td>n.a.</td>
<td>31</td>
<td>26</td>
<td>81</td>
<td>n.a.</td>
<td>188</td>
</tr>
<tr>
<td>32</td>
<td>n.a.</td>
<td>32</td>
<td>22</td>
<td>70</td>
<td>n.a.</td>
<td>165</td>
</tr>
<tr>
<td>M (SD)</td>
<td>26.7 (5.5)</td>
<td>26.9 (3.7)</td>
<td>80.9 (7.5)</td>
<td>89.4 (10.2)</td>
<td>185 (6)</td>
<td>187 (7)</td>
</tr>
</tbody>
</table>

Note. League refers to the competition level in German leagues (0 is no competitive experience and 6 is competitive experience in the German second Bundesliga). The defenders were aware of the manipulation in this study (they served as confederates); therefore some of the defenders played the defender to more than one attacker and some had played the attacker before knowing about the manipulation. When a participant was defender and not attacker this is denoted by n.a. on the place of the attacker (e.g., participant 32).
For the experiment proper, participants were allowed three familiarization trials. On each trial one experimenter called out the name of the defender and signaled the posture condition, imperceptible to the attacker. The defender’s bounce-pass to the attacker marked the beginning of the trial and was later used to synchronize the images of the two cameras.

Data reduction and statistical analyses

For each trial we reviewed the exploratory actions of the one-on-one subphase and identified the video frame immediately before the attacker initiated a definitive drive to the basket. This moment was the first frame in which one of the feet started losing contact with the floor in preparation for the upcoming drive. Intra- and inter-rater reliability for the identification of drive initiation moments were respectively \( z = .95, p < .05 \) and \( z = .92, p < .05 \). [We selected the trials where the attacker faced the defender during the exploration movements because we wanted to make sure the attacker had access to posture information from the defender. This was done by selecting the trials that fulfilled these two conditions: (1) the midpoint between the defender’s two feet was closer to the basket than either foot of the attacker; and (2) the angle between the defender’s feet and the attacker’s feet was larger than 90°. On average there were eight trials per participant excluded from further analysis because the attacker was not facing the defender, which constitutes 17% of the trials.] In the video frames corresponding to drive initiation we digitized a point on the shoes of both participants. Then we defined (1) the vector between the midpoint of the attacker’s/defender’s feet and the basket; (2) the angle between this vector and the positive x-axis; and (3) the angle between the participants’ feet (taking left foot as reference) and the x-axis. To calculate the angular postures, we subtracted angles 2 and 3 (here, 270° means that both feet were equidistant from the basket, angles smaller than 270° mean the defender had his right foot advanced, and angles larger than 270° mean the defender had the left foot advanced; Fig. 2). To calculate the distances between the attacker and the defender we subtracted vector 1 of the attacker from that of the defender. The average plus or minus one standard deviation was used as a cutoff point, scaled for each dyad, between small and large distances between the attacker and the defender, which we used to analyze the angular postures separately. For each participant and condition we also calculated shooting accuracy as the percentage of balls that passed through the basket of all the balls shot at the basket. We used WinAnalyze for the digitization and Matlab for all calculations.

Shooting accuracy was submitted to a Mann–Whitney U test for nonparametric distributions. For small and large distances between the attacker and defender, we submitted the angles related to position of the feet of the attacker and the defender (dependent variables) to repeated-measures analyses of variance with factors drive direction (2 levels: left and right), and group (2 levels: novice and intermediate).

Results

Shooting accuracy

The intermediate group showed a significantly larger percentage of successful shots than the novice group, \( U(23) = 38.00, p = .05 \). The average percentage of successful shots for the intermediate group was 46%, \((SD = 9)\), whereas for the novice group it was 38% \((SD = 16)\). This group effect was in accordance with previous experimental studies (e.g., de Oliveira et al., 2009).

Effect of the posture of defenders on the drives of attackers

At small distances between the attacker and the defender, the posture of the defenders had a significant main effect on the drives of the attacker, \( F(1, 23) = 7.03, p < .05, \eta^2 = .23 \). Leftward drives occurred at smaller angles \((M = 262°, SD = 10)\) that corresponded to the defender having his right foot advanced. Rightward drives occurred at larger angles \((M = 270°, SD = 7)\) that corresponded to the defender having his left foot advanced (Fig. 3). There was no significant main effect of group, \( F(1, 23) = 1.75, p = .68 \), and no significant Drive \(\times\) Group interaction, \( F(1, 23) = 0.1, p = .92 \).

At large distances between the attacker and the defender, there were no significant main effects of drive, \( F(1, 23) = .22, p = .64 \), or group, \( F(1, 23) = .43, p = .52 \), and no significant Drive \(\times\) Group
interaction, $F(1, 23) = .05, p = .83$. In line with our hypothesis, these results show that the attackers used drives to the side of the most advanced foot of the defender when they were engaged in a dyad at small distances between the attacker and the defender. In addition, the use of this posture information was not specific to the expertise levels in this study.

**Posture of attackers and their own drives**

The posture of the attackers had a significant main effect on the direction of their own drive, $F(1, 23) = 16.07, p < .01, \eta^2 = .41$. They used drives to the left when their left foot was already advanced ($M = 257^\circ, SD = 16$), whereas they used drives to the right when their right foot was advanced ($M = 274^\circ, SD = 18$). There was no significant main effect of group, $F(1, 23) = 1.11, p = .30$. Importantly, there was a significant Drive × Group interaction, $F(1, 23) = 10.42, p < .05, \eta^2 = .31$, caused by larger angular differences in the novice than in the intermediate group (novice: $M = 251^\circ, SD = 14$ vs. $M = 285^\circ, SD = 13$; intermediate: $M = 262^\circ, SD = 17$, vs. $M = 265^\circ, SD = 17$; Fig. 4). This result indicates that the novice and intermediate participants in this study moved their most advanced foot at the moment of drive initiation, corresponding to their upcoming direction of drive. The implication is that this posture information was available to their defender and more prominently so in the novice group.

**Discussion**

In the present study, we investigated the use of one information source that can guide the decision about direction in the basketball drive. We manipulated and measured the posture of the defender (confederate) and observed the drive direction of the attacker (naive participant). In agreement with our hypothesis, the drive direction chosen by the attacker was significantly related to the posture of the defender immediately before the initiation of the drive. The attackers performed significantly more drives to the side of the most advanced foot of the defender. Driving to the side of the most advanced foot of the defender has important functional implications, because it takes longer for the defender to recover position and protect the basket. In addition, posture information of the defender was related to drive direction of the attacker at the novice and intermediate levels. The distance between the attacker and the defender proved to be a relevant constraint in the use of posture information. Whereas at small distances attackers relied on posture information to make their decision, at large distances posture was unrelated to drive direction. Our results suggest that the novice group revealed information regarding the upcoming drive direction, while attackers in the intermediate group were able to conceal it from the defender.

In this study, we treated decision making as an active process of acting on the affordances available in the environment (e.g., Araújo et al., 2006). Our results indicate that contextual information (e.g., posture of defender) directly contributed to the guidance of decision behavior, which is in line with other studies (e.g., Cordovil et al., 2009; de Oliveira et al., 2009; Williams et al., 1999). Moreover, the decision on drive direction at both levels of expertise was based on the transient posture of the defender. By acting on an affordance related to the information available in the current context, the attacker can rely on prospective information about the future state of the player–environment system, which is an effective means to control action and achieve task goals (Fajen, 2007). It has been argued that the direct perception of affordances depends on the level of attunement of the individual to relevant properties of the environment (Turvey, 1992). The fact that both groups acted on the posture information in a similar way indicates that novices may be attuned to information related to the posture of the opponent before their perception–action links are fine-tuned (e.g., Pepping & Li, 1997).

In this study, the distance between attacker and defender proved to be a relevant constraint in the use of posture information for drive direction. Apparently, at smaller distances (scaled for each dyad), attackers drove to the side where it was more difficult for the defender to maintain stability or symmetry with his opponent. In recent studies, distance between attacker and defender has appeared as a crucial constraint on the decision dynamics of the one-on-one subphase (Araújo et al., 2006; Davids, Button, Araújo, Renshaw, & Hristovski, 2006; Passos et al., 2008). Interestingly, the goal path selection has been viewed as emerging from the intrinsic metric of the system composed by the attacker with the ball and the direct defender. The present results support the role of distance between players, together with posture information, as relevant constraints that channel goal-directed behavior (Araújo et al., 2004; Davids et al., 2006).

Equally important to picking up relevant information about the opponent is the ability to conceal relevant information about one's
own future action. In contrast with novices, participants at the intermediate level were more proficient at concealing information about the future direction of their drive. The refinement of the link between the information perceived and the action system (i.e., calibration) makes goal-directed behavior more efficient (Fajen et al., 2009). Probably, as a result of their greater experience, intermediate-level attackers were able to perceive action possibilities in intrinsic units and act on posture-related information by concealing information about the upcoming drive direction. Predictable behavior in novices may reflect the need for further refinement of the link between information and the action system (Montagne, 2005). In fact, the use of information to conceal future drive direction is task specific in terms of information pick-up (Raab, de Oliveira, & Heinen, 2009). These results express subtle adaptations in the functional interaction between the attacker and defender that could not be captured by the prevalent video simulation designs. They also emphasize the importance of preserving the coupling of perception and action between individuals to describe social behavior (Araújo et al., 2007; Marsh et al., 2006).

This study contributes to the understanding of interpersonal motor coordination, going beyond coordination itself and showing the goal-directness and information-based control of interpersonal actions under constraints. Further identification of other constraints (e.g., footedness), for example, on the two-on-two subphase of basketball, may contribute to a deeper understanding of the decision process in sport settings. There are a number of implications from this study relevant to the organization of training sessions in basketball (see Araújo, Davids, Chow, & Passos, 2009), we mention two. First, the design of representative tasks may allow athletes to detect posture-related affordances within the environment. Instead of repeating predetermined solutions, creating tasks that include relevant constraints of the game may promote adaptive behaviors with high potential for generalization. Second, from early in the training process it is feasible to create a context where novice basketball players can explore postural information to solve the one-on-one subphase. However, training that is aimed at consolidating relevant links between perception and action should take into account the fragile nature of these links, especially in relation to unpredictable behaviors. The information demands may require prior stabilization of functional links with the action system and then a complementary process of exploiting these links (Araújo et al., 2009).

Past research has mostly focused on perception isolated from action, which has led to the identification of visual information for perception. However, future research may benefit from sampling relevant contextual information of sports settings in experimental task designs that preserve functional links between perception and action.

Acknowledgments

The authors are grateful to Franziska Lautenbach and Diane Lenz for their assistance in scheduling participants and data collection. Thanks also to the participants who volunteered to participate in this study.

References