European Journal of Sport Science
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tejs20

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Version of record first published: 06 Jul 2012

European Journal of Sport Science
2012, 1–8, iFirst article

Routledge
Taylor & Francis Group

ORIGINAL ARTICLE

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Abstract
This study evaluated effects of defensive pressure on running velocity in footballers during the approach to kick a stationary football. Approach velocity and ball speed/accuracy data were recorded from eight football youth academy participants (15.25, SD = 0.46 yrs). Participants were required to run to a football to cross it to a receiver to score against a goal-keeper. Defensive pressure was manipulated across three counterbalanced conditions: defender-absent (DA); defender-far (DF) and defender-near (DN). Pass accuracy (percentages of a total of 32 trials with 95% confidence limits in parenthesis) did not significantly reduce under changing defensive pressure: DA, 78% (55–100%); DF, 78% (61–96%); DN, 59% (40–79%). Ball speed ($m \cdot s^{-1}$) significantly reduced as defensive pressure was included and increased: DA, 23.10 (22.38–23.83); DF, 20.40 (19.69–21.11); DN, 19.22 (18.51–19.93). When defensive pressure was introduced, average running velocity of attackers did not change significantly: DA versus DF ($m \cdot s^{-1}$), 5.40 (5.30–5.51) versus 5.41 (5.34–5.48). Scaling defender starting positions closer to the start position of the attacker (DN) significantly increased average running velocity relative to the DA and DF conditions, 5.60 (5.50–5.71). In the final approach footfalls, all conditions significantly differed: DA, 5.69 (5.35–6.03); DF, 6 .22 (5.93–6.50); DN, 6.52 (6.23–6.80). Data suggested that approach velocity is constrained by both presence and initial distance of the defender during task performance. Implications are that the expression of kicking behaviour is specific to a performance context and some movement regulation features will not emerge unless a defender is present as a task constraint in practice.

Keywords: *Kicking, football, ecological constraints, representative design, perception-action coupling*

Introduction

Kicking is a key behaviour in football that fulfils dynamic offensive and defensive requirements of performance. A principal aim in football research is to provide information that may enhance effectiveness of athletes when learning to kick in different performance contexts (Ali, 2011). A popular research paradigm for informing design of the constraints of kicking tasks has been observations of the approach patterns for maximal instep kicking of stationary balls. Examples of such investigations range across single condition (descriptive studies) and experimental studies (Kellis & Katis, 2007; Lees, Asai, Andersen, Nunome, & Sterzing, 2010).

Typically, kicking behaviour is measured relative to accuracy and/or ball speed outcomes. To expose the nature and potential mechanism of speed/accuracy trade-offs potential constraints that influence ball speeds are typically investigated by varying their values across a range (such as allowable approach velocity). Research suggests that there are a number of consistent inter-individual and intra-individual characteristics of the approach run to kick a football, all of which can influence the subsequent ball flight (Davids, Lees, & Burwitz, 2000; Kellis & Katis, 2007). In terms of optimising ball speed, inter-individual characteristics include adopting: an angled approach relative to the direction of ball flight (Egan, Verheul, & Savelsbergh, 2007; Isokawa & Lees,

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ISSN 1746-1391 print/ISSN 1536-7290 online
http://dx.doi.org/10.1080/17461391.2012.696712

1988); a multi-stepped running approach (Andersen & Dörge, 2011); a large final step into the foot plant position that supports the kicking leg (Lees et al., 2010; Lees, Kershaw, & Moura, 2005) and, a body velocity of around 4.5 $m \cdot s^{-1}$ (Andersen & Dörge, 2011). Andersen and Dörge (2011) also showed that ball speeds can reduce by as much as 50% when skilled kickers are instructed to adopt approach speeds and stepping patterns different to their self-preferred.

During performance, players kick a ball with accuracy demands that are dynamic (such as a moving teammate). When attempting to maximise ball velocity under accuracy constraints, it is well documented that a speed/accuracy trade-off commonly emerges (Kellis & Katis, 2007). In football kicking, when the requirement to hit an external target is introduced, there have been reports of reductions in movement velocity of body segments (Lees & Nolan, 2002; Teixeira, 1999), and reductions in subsequent ball velocities (Andersen & Dörge, 2011; Asami, Togari, & Kikichi, 1976). It is also believed that contextual factors that exist in games also have a substantive influence on kicking performance (Ali, 2011; Kellis & Katis, 2007). However, currently, it is unclear how speed/accuracy considerations transfer to performance contexts; for instance, how speed/accuracy trade-offs are influenced by the presence of an opposing player.

There is also a distinction to be made between kicking as a technique compared to kicking as a skilled behaviour (Ali, 2011; Davids et al., 2000). In terms of skilled behaviour, kicking is an expression of 'correct technique as determined by demands of the situation' (Ali, 2011, p. 171). Ali (2011) also suggested that previous research to evaluate kicking performance has been 'too simplistic' in that the experimental design typically has not included the ecological constraints that exist in performance settings, such as the presence of opposing defenders (pp. 179–180; see also, Kellis & Katis, 2007, p. 163). Research on the interceptive action of cricket batting has also emphasised this point. When skilled cricketers intercepted a ball projected by a ball machine compared to when the ball was delivered by a bowler, batters significantly delayed their movement organisation and the quality of bat–ball contact in their stroke reduced (Pinder, Davids, Renshaw, & Araújo, 2011). Fundamentally, the data showed that, depending on the task constraints, cricketers adapted by organising their movements relative to the information available.

The implication is that by using 'representative design' principles (the degree to which an experiment accurately samples the task relevant information present in a performance competitive context) in studies of football actions, research can expose performance constraints that football players engage with and which influence the effectiveness of kicking behaviours (see also: Araújo & Davids, 2009; Glazier & Davids, 2009; Lees, 2002). Efforts to undertake research which has representative design acknowledge that actions such as kicking are functional when they are embedded within a performance context (Araújo, Davids, & Hristovski, 2006).

Accordingly, the purpose of this study was to evaluate the influence of varying levels of defensive pressure on the approach velocities of skilled attackers in the run-up to a crossing task under general instructions (i.e. we deliberately provided participants with no specific speed/accuracy instructions on how to cross the ball). To achieve our aims, attacking players were observed running to kick a ball to a teammate when no opponent was present, when an opponent was initially positioned at a far distance from the ball, and when an opponent was initially positioned at a closer distance.

In the current study, our experimental design was influenced by data reported by Dicks, Davids and Button (2010) showing that during a penalty kick situation, the faster the goal-keeper, the longer was the delay in time at which the goal-keeper initiated their interceptive action. The movement delay was functional in that it allowed goal-keepers to pick up information about the intended direction of the kick from the kicker's run-up. These findings were consistent with Fajen's (2005) model of affordance-based control that proposes the control of actions is informed by a sensitivity to boundary regions of one's own action capabilities for a given affordance.

An affordance is an opportunity for action specified in the environment relative to the performer's personal constraints and state of movement (Fajen, Riley, & Turvey, 2009; Gibson, 1979). According to Fajen (2005), affordances in visually guided actions are predicated on one's action capabilities. Action capabilities are an individual's functional characteristics (such as running speed) that define the boundaries that separate possible from impossible actions relative to some environmental challenge (Fajen, 2005). An action is possible as long as an ideal state, such as the minimum required velocity to get to a ball before an opponent, does not exceed a performer's capacity to achieve it (e.g. exceeds their maximal running velocity) (Fajen, 2005).

Previous research has shown that humans can perceive affordances for themselves (Warren, 1984) and for others (Stroffegen, Gorday, & Sheng, 1999) and, that action capabilities, such as maximum jump height, are perceived in a context-specific manner (Weast, Shockley, & Riley, 2010). For example participants will vary judgements of affordances to account for fatigue (Pijpers, Oudejans, & Bakker, 2007) or requirements to wear ankle weights

(Ramenzoni, Riley, Davis, Shockley, & Armstrong, 2008). These findings provide strong evidence that performers use their perception of action capabilities in realising an affordance.

In this article we sought to influence the boundaries that enable an attacker to run to and kick a stationary ball based on observed action capabilities of each attacker and defender participating in the run and kick task. We expected that the positioning and movements of the defender would be a significant source of information, throughout the run-up, requiring participants to make adjustments in approach velocity over the footfalls leading into the kick. By scaling a defender's initial position closer, attackers would be required to perceive prospectively, the revised boundaries separating the possibility of generating a kick, and based on these perceptions, increase running velocity closer to their maximum capability.

Methods

Participants

Male, right-footed, football academy members, ($n = 8$, age = 15.25 yrs, SD = 0.46 yrs; formal training and competitive experience = 8.25 yrs SD = 2.12 yrs), and their parent guardians signed information and consent forms prior to undertaking the experiment as approved by the lead author's local University Ethics Committee.

Task and apparatus

Figure 1a depicts the nature of the task and the roles required by participants in the experiment. In the defender-absent (DA) condition three participants were involved in the task: (1) an attacker, (2) a receiver and (3) a goal-keeper. The attacker was required to sprint to a ball (regulation size 5) and cross it back towards the penalty spot. Positioned at the penalty spot, a receiver was targeted for the cross to attempt to score. When a defender was present, in defender-far (DF) and defender-near (DN) conditions, the number of participants involved in the subphase was four (as represented in Figure 1a). The defender was instructed to run and meet the attacker at the earliest point and prevent the cross within the laws of the game. Laws of the game were enforced by a qualified referee positioned in the field (participants' regular outdoor grassed training field used to ensure familiarity). Task initiation was at the attacker's discretion after the referee's signal. It was most important that participants were not given specific instructions on how to undertake the task. The aim of implementing such general instructions was to study the adaptive coordination patterns that emerged under the interacting task constraints of participant intentionality, the players' distance to a stationary ball to be kicked, and the different levels of defensive pressure.

Pilot work

To verify a defender's starting position relative to an attacker and the position of the stationary ball, pilot work established the time it took each: (1) attacker to sprint 20 m and cross a stationary ball (video recording the first frame of forward movement to the frame prior to foot-to-ball contact); and (2) defender to sprint past a line 20 m away (using timing gates). This information was used to position each defender's initial starting distance from the ball relative to the attacker (Figure 1a), because it allowed us to predict the distance the defender could cover in the same amount of time that it would take the attacker to run and kick a ball positioned 20 m away. This distance value was then multiplied by 0.2 (i.e. 20%) in order to determine the distance from the ball of the defender in the DF condition, and by 0.1 (10%) to determine the distance of the defender from the ball in the DN condition (Figure 1a).

Data capture

Two cameras (Sony HDR-XR520V and Sony HVR-V1P), positioned perpendicular to the running direction of the attacker, captured raw data from the locomotor patterns of the attacking participant. Shared visual angles captured the entire run-up and cross action (Figure 1b). The performance area was surrounded by high visibility markers providing control points for two-dimensional direct linear transformation. These were positioned in the corners of 5 m × 5 m measured squares that extended from the corner of the field and along the side-line (Figure 1b). The foot positions were digitised relative to the control points and were visibility markers (2.5 cm wide × 5 cm height). The shoe markers were positioned 2.5 cm from the heel mid-line on the outer right foot and 2.5 cm from the heel mid-line of the inner left foot (Figure 1b), in both cases positioned at the intersection between the outsole and the ground surface. Pilot work established accuracy using marked shoes positioned at known locations throughout the performance area. The digitised coordinates of the shoes were compared to measures made using tape. The mean differences ($n = 13$) between the real and digitised points were 1.53 ± 0.63 cm, similar to data recorded in previous studies of this type (e.g. Lee, Lishman & Thomson (1982 ~ 1 cm); Maraj, Allard, & Elliott (1998 = 1.5 cm)) and acceptable for the stated purposes of this study. Intra-class reliability measures were also

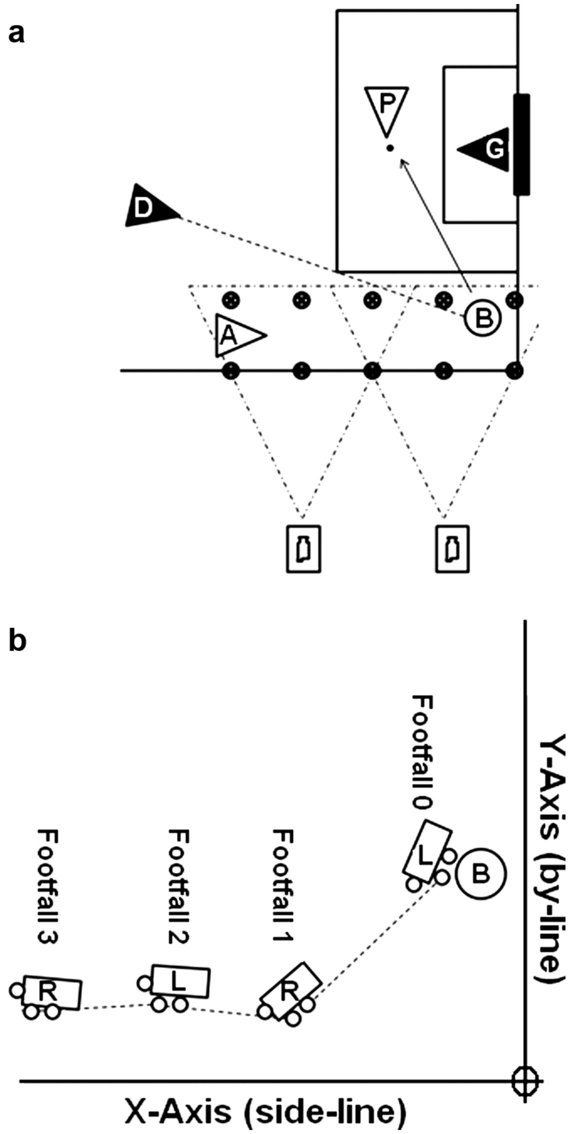

Figure 1. Schematic of the experimental task and footfall notation method. A, Attacker; B, Ball; D, Defender; G, Goal-keeper; L, Left foot; P, Pass Receiver; R, Right foot. (a) The positions of the ball, participants and goal. The dashed line from the ball to the defender varied in length from the ball depending on the member's relative movement speeds and whether it was the defender-far or defender-near condition. The line from the ball to the defender intersects with the top corner of the 18-yard box. The arrow from the ball to the pass receiver indicates the intended kicking direction of the attacker. The 10 encircled X's represent the control points. These were positioned along the side-line, by-line and were within the performance field. Each control point was separated by 5 m to their nearest neighbours. Cameras were positioned to view each half of the run-up surrounded by the control points. (b) The method of denoting the footfalls leading into the kick. For example in all conditions, footfall 0 was the footfall that supported the kicking leg and was always the left foot. Note also that the position of the footfalls were digitised at the middle shoe marker (in the diagram shown as open circles on each foot).

determined on the final 13 footfalls of randomly selected trials ($n = 12$) and returned high correlations ($r = 0.940$), while inter-class correlations of the same trials relative to a second trained researcher were also high, $r = 0.910$.

Once digitised, the shoe markers and ball were plotted as x–y coordinates relative to X–Y axes of the by-line (X-axis) and side-line (Y-axis) (Figure 1b). Running velocity (central moving differences method) was derived using the frame rate (25 Hz) and the distance covered between footfalls (Hamill & Knutzen, 2003). The temporal reference for each footfall was taken at the frame prior to the frame in which the participant's knees crossed during the stance phase (as per Berg & Mark, 2005).

In order to observe cross performance outcomes, pass accuracy and ball velocity data were recorded. To collect ball peak speed data due to the kick, a sports radar gun (Stalker Radar, Texas) was used. Pass accuracy was assessed whereby, if the receiving target player touched the ball post cross, an accuracy score of 1 was coded, and if the receiving player failed to touch the ball, pass accuracy was coded 0.

Experimental design

Participants undertook blocks of four repeated trials (with two-minute rest periods between trials) counterbalanced across each of the three conditions and using a quasi-Latin square design (eight-minute rest periods between conditions). Observation sessions were recorded within a one-week time period in dry weather conditions whilst participants were wearing competition clothes and equipment (including studded boots and shin pads).

A three level (DA, DF, DN), one-way ANOVA with repeated measures was performed on the data after verifying that all the assumptions were met with due corrections for violation of the sphericity assumption (Shutz & Gessaroli, 1987). Follow up tests using planned contrasts evaluated differences between conditions: DA versus DF, DA versus DN and DF versus DN. Attacker-defender participant dyads were formed by random assignment.

Results

The aim of this study was to evaluate the influence of defensive pressure on the approach velocities of skilled attackers in the run-up to a crossing task. Table I contains the main effects of defensive pressure (three levels: DA, DF and DN) on overall mean run-up velocities, peak ball velocities and pass accuracies. Tabled are also the planned contrasts, DA versus DF, DA versus DN and DF versus DN, carried out to determine significance of these comparisons.

Table I. Main effects and planned contrasts between the three conditions of defensive pressure

	Main effects	Conditions			Planned contrasts		
		Mean, 95% CI			$F(1,7)$, 1-β, ε		
Variable	$F(2,14)$, 1-β, ε	DA	DF	DN	DA × DF	DA × DN	DF × DN
Accuracy (1 = r, 0 = nr)	1.34, 0.24, 0.16	0.78, 0.55–1.00	0.78, 0.61–0.96	0.59, 0.40–0.79	0.00, 0.05, 0.00	1.12, 0.16, 0.15	2.74, 0.23, 0.28
Peak ball vel (m·s^{-1})	**32.39**, 1.00, 0.82	23.10, 22.38–23.83	20.40, 19.69–21.11	19.22, 18.51–19.93	**25.72**, 0.99, 0.79	**51.61**, 1.00, 0.88	**8.74**, 0.72, 0.56
Mean running vel (m·s^{-1})	**8.69**, 0.93, 0.55	5.40, 5.19–5.61	5.41, 5.26–5.56	5.60, 5.39–5.80	0.09, 0.06, 0.01	**57.12**, 1.00, 0.89	**7.41**, 0.65, 0.51

Note: Significant main effects and planned contrasts highlighted bold at $P \leq 0.05$. CI, confidence intervals; 1-β, Power; ε, Eta squared; df, Degrees of freedom; DA, Defender-absent; DF, Defender-far; DN, Defender-near; r, received; nr, not received.

Pass speed/accuracy

Notably, there were no significant differences between conditions for pass accuracy measures. On average over the three conditions, participants accurately crossed the ball to the receiver 72% of the time. In contrast, participants significantly reduced the velocity at which they kicked the ball when under defensive pressure. As the starting position of the defender was scaled closer to the ball, velocities significantly declined. There was a large and significant reduction in ball velocity observed from the DA to the DF condition (11.69%), and a further 5.78% reduction in ball speed between the DF and the DN conditions (Table I).

Running velocity

Overall mean running velocity of the attacker did not significantly change in the DA condition compared with the DF condition (5.41 m·s^{-1}) across these two conditions. However, in the DN condition a large and significant increase in average running velocity emerged with participants running 3.61% faster than the average of the running velocities of the DA and DF conditions.

In order to examine peak running velocity, planned contrasts of the running velocities at each footfall (Table II) were undertaken and showed two key differences between the DA and DF conditions: (1) the participants significantly increased their peak running velocity by 6.46% (notably, peak running velocity in the DA condition was recorded at 7 footfalls from the ball, and in the DF condition was recorded 6 footfalls from the ball); and (2) at 1 footfall from the ball travelled on average 32.65% slower in the DF condition. These two features of the DA and DF footfall-to-footfall velocity data indicate that the deceleration process of an attacker running towards a ball was significantly more abrupt when defenders were included as a task constraint.

When comparing the running velocity at footfalls between the DA and DN conditions (Table II), similar conclusions can also be drawn in that in the DN condition there emerged: (1) a delay in the footfall when participants began to reduce running velocity before arriving at the ball; (2) a 11.26% larger peak velocity at the footfall prior to the footfall in which participants began to reduce running velocity; and (3) a significant 23.62% reduction in running velocity at footfall 1 compared to the DA condition.

The final contrast performed, between the DF and DN conditions (Table II), revealed that during the deceleration footfalls (footfalls 6-to-1), participants were travelling significantly faster at footfalls 5, 3 and 2 in the DN condition. By footfall 1, participants were travelling at velocities not significantly different to each other (an average 2.47 m·s^{-1}).

Discussion

This study demonstrated that running velocities during the approach to cross a stationary ball are shaped by: (1) presence of a defensive player and (2) the starting distance of a defender that was scaled according to the action capabilities of both the attacker and the defender.

Analysis of the overall average running velocity data to interpret the influence of defensive pressure (Table I), suggests that, for participants to significantly alter their self-preferred overall running velocity, it was not sufficient to merely include the presence of a defender in the task. The constraint of defensive pressure on run-up behaviours was also dependent on the distance at which the defender was initially positioned. However, by comparing the running velocities between conditions at each footfall leading into the cross (Table II), the data show that despite no changes in the average running velocity between the DA and DF conditions, participants decelerated more abruptly in the presence of a defender. This observation suggests that control of

Table II. Main effects, means and planned contrasts at each footfall

	Main effects	Running velocity ($m \cdot s^{-1}$)			Planned contrasts		
		Mean, 95% CI			$F(1,7)$, 1-β, ε		
Footfall	$F(2,14)$, 1-β, ε	DA	DF	DN	DA × DF	DA × DN	DF × DN
12	1.54, 0.27, 0.18	5.13, 4.86–5.40	4.92, 4.63–5.22	4.94, 4.54–5.34	2.49, 0.28, 0.26	2.45, 0.22, 0.26	0.02, 0.05, 0.00
11	0.71, 0.15, 0.09	5.59, 5.38–5.79	5.49, 5.20–5.77	5.48, 5.15–5.82	0.85, 0.13, 0.12	0.99, 0.14, 0.12	0.00, 0.05, 0.00
10	0.35, 0.10, 0.05	5.58, 5.54–6.07	5.86, 5.59–6.13	5.56, 5.56–6.20	0.27, 0.07, 0.04	0.73, 0.12, 0.10	0.05, 0.05, 0.01
9	0.96, 0.18, 0.12	5.98, 5.68–6.28	6.04, 5.88–6.20	6.12, 5.79–6.45	0.44, 0.09, 0.24	2.16, 0.25, 0.24	0.47, 0.09, 0.06
8	**3.91, 0.61, 0.36**	5.97, 5.75–6.20	6.21, 6.02–6.40	6.19, 5.95–6.42	**6.47, 0.59, 0.48**	***4.33, 0.44, 0.38***	0.09, 0.06, 0.01
7	**9.06, 0.94, 0.56**	6.04, 5.85–6.24	6.19, 6.02–6.37	6.39, 6.16–6.62	2.68, 0.29, 0.28	**20.17, 0.97, 0.74**	**6.76, 0.61, 0.49**
6	**15.39, 1.00, 0.69**	6.02, 5.76–6.28	6.43, 6.30–6.57	6.72, 6.38–7.06	**12.96, 0.87, 0.65**	**41.48, 1.00, 0.86**	3.56, 0.37, 0.34
5	**32.48, 1.00, 0.82**	5.69, 5.35–6.03	6.22, 5.93–6.50	6.52, 6.23–6.80	**17.21, 0.94, 0.71**	**90.34, 1.00, 0.93**	**10.39, 1.00, 0.60**
4	**10.68, 0.97, 0.60**	5.62, 5.31–5.93	5.98, 5.60–6.37	6.22, 5.87–6.58	***4.93, 0.48, 0.41***	**48.98, 1.00, 0.88**	3.26, 0.35, 0.32
3	**7.61, 0.89, 0.52**	5.07, 4.78–5.37	5.22, 4.66–5.77	5.55, 5.18–5.92	1.08, 0.15, 0.82	**30.91, 1.00, 0.80**	**5.35, 0.51, 0.43**
2	**3.64, 0.57, 0.34**	4.39, 3.96–4.82	4.07, 3.39–4.76	4.52, 4.01–5.04	2.41, 0.27, 0.12	0.96, 0.14, 0.12	**7.30, 0.64, 0.51**
1	**14.98, 1.00, 0.68**	3.43, 2.88–3.99	2.31, 1.51–3.11	2.62, 1.90–3.34	**25.48, 1.00, 0.78**	**11.60, 0.83, 0.62**	3.44, 0.36, 0.33

Note: Significant main effects and planned contrasts at $P \leq 0.05$ in bold. Those different between $P \leq 0.10$ and > 0.05 in bold italic. CI, upper and lower bound 95% confidence intervals for the true value of the mean; 1-β, Power; ε, Eta squared; DA, Defender-absent; DF, Defender-far; DN, Defender-near.

running velocity depended on both the defender's presence, and the initial distance at which the defender was positioned.

On preliminary interpretation, the data suggest that during the process of preparing to kick the ball in the DA condition, participants focused on managing the relationship to the ball, enabling an approach that maximised ball speed. In contrast, when defenders were present, the increase in velocity from DF to DN suggested that participants generated adjustments during the approach based on the initial and ongoing positioning of the defender (consistent with a prospective management of the defenders position over the course of the run-up; Montagne, 2005).

Importantly, at 1 footfall from the ball, participants were travelling more slowly when under defensive pressure. The findings in this study are consistent with the presence of a speed/accuracy trade-off (Plamondon & Alimi, 1997) in that the alterations in approach velocity occurred at the expense of maximising ball speed (similar to Andersen & Dörge, 2011) but, not at the expense of task success. Indeed, attackers were highly successful at perceiving the ongoing action capabilities of their opponent with only one successful interception which occurred in the DN condition – all other kicks were successfully completed and the ball projected beyond the opponent's reach.

Fajen's model of affordance-based control was developed using studies of driver breaking behaviour (Fajen, 2005; Fajen & Devaney, 2006). To prevent a collision, performers tended to remain within a 'safe' performance region to ensure they maintained task success (i.e. they did not approach at a speed that prevented them from breaking to avoid a collision). In such a non-competitive context, the upper boundary of the action capability is defined by functional limits whilst, the lower boundary is a zero value number (Fajen, 2005). Under the task constraints of running to kick a stationary football, when no opponent was present, each performer could approach the ball with as much time as they liked. Indeed when under no defensive pressure, attackers took advantage of this and generated a run-up that maximised ball speed. Under competitive task constraints, the nature of the task meant that if the attacking players ran at a speed outside the 'safety' region (i.e. they moved too slowly), they would not have reached the ball with enough time to generate a kick. Therefore, when an opponent was present, the maximal running speed of the opponent determined the minimum speed the attacker needed to run in order to reach the ball first with enough time and space to kick it without interception. This finding shows that the attacking players were capable of perceiving the affordances for the defender (i.e. the time the defender required to reach the ball as a function of their action capability).

A clear conclusion of the current study is that control of movement parameters important for kicking is informed by the constraints of each specific performance context. Stability of self-preferred approach velocity into a kick by skilled participants was not transferred to performance contexts where a defender was present as a task constraint. Research on gaze-behaviour may help explain the clear differences that emerged between the conditions where a defender was absent or present (Dicks, Button, & Davids, 2010; Foulsham, Walker, & Kingstone, 2011; Laidlaw, Foulsham, Kuhn, & Kingstone, 2011). For example, Dicks, Button and Davids (2010) showed that when goal-keepers were required to verbalise the direction they would undertake an interception (but not generate the action), a higher percentage of gaze fixations on the kicking player occurred compared to on the ball. When the goal-keepers were required to physically intercept the ball, the percentage of kicker and ball gaze fixations were almost equal. Taken alongside the current study, the findings reveal the effects of the complex intertwined relationship between intentions, perception and action on the emergent movement behaviours of individuals during performance in sport.

Future research needs to carefully consider the relationship between information and movement in the football run-up when designing experiments. This is not to say that the current model of the instep kick is invalid, rather, there is however, clear scope for considering what factors from the performance context can constrain the emergence of (stabilise or destabilise) this kicking action.

Predicated on applying representative design principles, the findings of this study provide a number of fruitful avenues for future research on the football kick. For example, there is a need to evaluate how elite level performers manage the inter-personal distance to the defender in a manner that enables them to maximise ball speeds. They may well, for example, run at a speed as close as possible to the lower boundary that enables a kick to be realised. Alternatively, at some point in the run-up, it may be useful for performers to realise a different affordance; for example rather than kicking the ball, taking possession of the ball and dribbling it may be a more functional tactical action. Understanding what the critical values might be, in terms of the distance between the attacker and defender, when such strategic behaviours emerge could provide a valuable pedagogic method. For example in cricket batting, when a ball bounces within a certain distance from the wicket, both forward and backward defensive batting drives appear equally probable (Pinder et al., 2011). The implication being that careful manipulation of such informational constraints through the use of an appropriate model of the learning may enable performers to explore the thresholds of different functional behaviours (e.g. Chow, Davids, Hristovski, Araújo, & Passos, 2011; Frank, Michelbrink, Beckmann, & Schöllhorn, 2008).

The limitations in the current study, however, are that determination of the upper limits of each participant's action capabilities required a separate day of testing to that of the experiment. Although unlikely, it is conceivable that action capabilities could change even over the course of a single day. Additionally, the hypothesis that the attacker was managing the distance to the defender would be strengthened by acquiring data on the defender's position over time and also eye-tracking data from the attackers might help elucidate in what way the defender is being used to regulate the approach.

In summary, the findings in this study confirm the notion that expression of kicking technique is specific to the constraints of a performance context. Movement regulation features, such as approach velocity parameters, appear not to emerge unless a defender is present as a task constraint. Indeed, there is evidence to suggest that the kickers generated regulations on the basis of an ability to perceive the affordances for the defender. The findings extend the methods available for observing the skill of kicking in football by accounting for the task specific action capabilities of each participant.

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