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Field location and player roles as constraints on emergent 1-vs-1 interpersonal patterns
of play in football

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1. Introduction

In the past decade researchers have increasingly recognized decision-making in team sports as one of the most influential aspects explaining performance (Araújo, Davids, & Hristovski, 2006; Gréhaigne, Bouthier, & David, 1997; Griffin & Butler, 2005; Turner & Martinek, 1995). Decision-making in team sports has been previously investigated with the aims of describing and explaining emergent behaviours of participants from an ecological dynamics perspective. Accordingly, decision-making emerges from a coupling of perception and action, predicated on individuals' action capabilities and information in a performance environment for identifying action possibilities (i.e., affordances) in line with specific intentions and task goals (Araújo et al., 2006; Fajen, Riley, & Turvey, 2009; Paterson, Van der Kamp, Bressan, & Savelsbergh, 2016).

This perspective proposes that decision-making should be investigated through identification of information that sustains individual behaviours and changes in emergent coordination tendencies between participants and teams (Araújo, Davids, Chow, & Passos, 2009; Passos, Araújo, Davids, & Shuttleworth, 2008). To achieve that aim, interactions between performers and their surroundings have been studied through identifying spatiotemporal patterns of interpersonal coordination that sustain actions in specific competitive performance contexts (Bartlett, Button, Robins, Dutt-Mazumder, & Kennedy, 2012; Castellano & Álvarez, 2013; Duarte et al., 2012; Sampaio, Lago, Gonçalves, Maças, & Leite, 2013; Travassos, Araújo, Vilar, & McGarry, 2011). In this line of reasoning, attacker-defender couplings have been deemed the fundamental unit of analysis for studying spatiotemporal relations that emerge between competing performers in team game performance (Davids, Araújo, & Shuttleworth, 2005; McGarry, Anderson, Wallace, Hughes, & Franks, 2002).

Previous research has sought to develop understanding of the forged and broken couplings that continuously emerge in attacker-defender dyadic systems. For instance, in basketball, interpersonal distance was identified as a key physical variable for explaining interpersonal interactions in a competitive dyadic system (Araújo et al., 2006). Following such ideas, it was observed in rugby union that interpersonal distance values of less than 4 m, combined with relative velocity of at least 1 m/s, was influential in predicting an attacker running past the defender with the ball in 1-vs-1 dyads (Passos, Araújo, Davids, Gouveia, et al., 2008). In football, the values of interpersonal distance and relative velocity, capturing interpersonal relations in such dyads have revealed some

1 contextual dependency, based on proximity-to-goal. Previous research has revealed that
2 changes in proximity-to-goal of 1-vs-1 (near to far from the goal) dyads influenced
3 decision-making behaviours and intentionality of participants in relation to the ball
4 (Headrick et al., 2011). In analyses of performance in 5-a-side futsal games it has also
5 been reported that the angle to the goal is a key informational variable that sustained
6 performers' behaviours in shooting at goal (Travassos et al., 2011; Vilar et al., 2012).
7 The relevance of this interpersonal relation needs to be considered to understand
8 decision-making behaviours in 1-vs-1 football dyads (Clemente, Couceiro, Martins,
9 Dias, & Mendes, 2013)

10 Based on these findings in the extant literature further work is needed to
11 consider variations in performance contexts of performance to provide information to
12 impact significantly on coaching practice (Mackenzie & Cushion, 2012). There is also a
13 need to understand how interpersonal patterns of coordination between attackers and
14 defenders in 1-vs-1 dyads are influenced by field location effects relative to the goal.
15 The specific aim of this study was to analyse patterns of interpersonal coordination that
16 sustain decision-making of performers in 1-vs-1 sub-phases of football in different field
17 locations near the goal (in left-, middle- and right- zones of the attacking third on field).
18 Based on previous work, we expected to observe an effect of field location on emergent
19 patterns of coordination in 1-vs-1 sub-phases. Furthermore, we also investigated effects
20 of players' roles (e.g., attackers, midfielders and defenders) on interpersonal patterns of
21 coordination that underpin decision-making in 1-vs-1 sub-phases in football. Based on
22 previous research (Gonçalves, Figueira, Maçãs, & Sampaio, 2014), suggesting that
23 different technical and tactical abilities of players with different roles support their
24 exploration of interpersonal relations with opponents, we expected to observe different
25 patterns of coordination emerging, depending on participants' main roles as defenders
26 or attackers.

27

28 2. Methods

29 2.1. Participants

30 Fifteen male players (under-15 yrs age group; mean age 13.2 ± 1.03 years; years of
31 practice 4.2 ± 1.10 years) participated in this study, categorised according to their team
32 role, resulting in 5 defenders, 7 midfielders and 3 attackers. All players were right-
33 footed and played in the club's first team. Players typically undertook four field training
34 sessions per week (~90 minutes per session) plus a gym session (~60 minutes per

1 session) to improve balance, coordination and strength, and played a competitive game
2 at the weekend. The club and parents of participants provided prior informed consent
3 for participation in the study. The study was approved and accepted by the Ethics local
4 Committee according to the Declaration of Helsinki.

6 2.2. Task and Procedures

7 Each participant was asked to perform in the role of a ball dribbler (attacker) and
8 defender at three field locations. Attacker-defender dyads competed in an area of 10 m x
9 5 m positioned to represent the different locations (described below) under competitive
10 performance conditions. The starting distance between attacker and defender was 3 m
11 (see Figure 1). At the end of this area, there was the goalkeeper's area. A regular size
12 football goal (2.44 m x 7.32 m) protected by a goalkeeper was used. Participants were
13 divided in three groups according their playing position on the field (defender,
14 midfielder or attacker). All participants performed in the 1-vs-1 trials starting from all
15 three zones as an attacker and also as a defender, resulting in a total number of 129
16 trials. In order to seek reliability of the tracking system, dyadic system opponents were
17 changed trial by trial (i.e., participants intermittently switched between acting as
18 attackers and as defenders from trial to trial). To ensure that participants sought to
19 constantly use adaptability during the emerging interactions in the dyads, we used a
20 sequential order to the roles participants were required to adopt between field zones. All
21 trials were initiated first from the right zone, then from the midfield zone and last from
22 the left zone. All the participants had time to rest between trials in order to avoid fatigue
23 effects. In order to ensure a balanced number of trials per player role, each defender
24 performed three trials, each midfielder performed two trials and each attacker performed
25 six trials in each field zone.

26
27 ***** Insert Figure 1 near here*****

28
29 Each trial started when both the attacking and defending participants were ready
30 in their starting positions and the attacking player was requested to start the trial. As
31 soon as attacker moved the ball, the defender was allowed to start defending. The
32 performance aim of the attacker was to dribble past the defender and shoot at goal. If
33 this occurred, the trial was over. The aim of the defender was to prevent the attacker
34 from scoring a goal, within the laws of the game. The trial was considered completed

1 when the ball moved outside the borders of the playing area (A regulation ball size 5
2 was used in all trials). All the trials that ended with a shot at goal or with the ball moved
3 outside the borders of the playing area, without the ball carrier dribbling past the
4 defender, were removed from further analysis in the study. The elimination of such
5 trials helped us to only capture and describe the interactional dynamics during
6 performance sequences when the ball carrier successfully dribbled past the defender.
7 Twelve trials in total were removed from further analysis for this reason.

8 Each participant's movements were captured by using a digital video camera
9 (Sony HRX-MC50E) placed 4 m above ground forming an angle of approximately 45°
10 with the longitudinal axis of the performance area to capture movements during the
11 whole task. All the video recordings captured the displacement trajectories of all
12 participants without moving the camera. The video recordings were digitized with
13 TACTO software (see, Duarte et al., 2010, for additional information). The displacement
14 trajectories of the ball and participants were tracked using a computer mouse, by
15 following, in every frame, the projection of their centre of gravity on the playing
16 surface. The obtained coordinates were transformed into real coordinates using the
17 direct linear transformation method (2D-DLT) and filtered with a Butterworth low pass
18 filter (6Hz) (Winter, 2005).

20 2.3. Reliability

21 Ten trials were selected at random and the displacement trajectories of attacker
22 and defender players (n=20) were re-digitised by the same experimenter. Intra-digitiser
23 reliability were assessed using technical error of measurement (TEM) and coefficient of
24 reliability (R) (N.B. $TEM = \sum D^2 / 2N$, where D is the difference between pre- and post-
25 test measures and N is the sample size. $R = 1 - TEM^2 / SD^2$, where SD is the standard
26 deviation of all measures) (Goto & Mascie-Taylor, 2007). The intra-TEM yielded
27 values of .254 m (2.43%) with a corresponding coefficient of reliability ($R=.981$).

29 2.4. Data Analysis

30 To measure variations in interpersonal patterns of coordination between
31 participants in the 1-vs-1 sub-phases, variations in relative distance between the attacker
32 and defender players to the centre of goal (RDPG), and the relative angle (α) between
33 the centre of goal, defender and attacker (RAGDA) (see Figure 1), were calculated,
34 based on methods used in previous research by Vilar et al. (2012). Values of RDPG

1 were calculated as the difference between the value of the attacker's distance to the
2 centre of the goal (DA) and the defender's distance to the centre of the goal
3 (DD). Values of RAGDA were calculated by measuring the inner product of the
4 defender's vector to the centre of the goal, and the defender's vector to the attacker (see
5 Figure 1). Due to differences in the temporal length of each trial, and for purposes of
6 comparison, each trial was normalized to the total time taken to perform the trial
7 independently. Data were averaged for every 10% portion of the total normalized time
8 in each trial. The value of 0% corresponds to the moment of trial initiation (when the
9 attacker was given a signal to start the trial with a dribble). The value of 100%
10 corresponded to the moment when the attacker moved into the target zone to shoot at
11 goal or when ball was played out of the performance area.

12 Magnitude-based inferences and precision of estimation were used to avoid the
13 shortcomings of research approaches supported by null-hypothesis significance testing
14 (Batterham & Hopkins, 2006). Comparisons of RDPG and RAGDA data among field
15 zones and players' roles were assessed via standardized mean differences, computed
16 with pooled variance and respective 90% confidence intervals (Cumming, 2012;
17 Hopkins, Marshall, Batterham, & Hanin, 2009). The field zones comprised the left,
18 middle and right performance areas, and the players' roles comprised the different
19 combinations of Defenders, Midfielders and Attackers, functioning as attackers or
20 defenders respectively (AADD – Attacker attacks, Defender defends (27 trials); AAMD
21 - Attacker attacks, Midfielder defends (27 trials); DAAD - Defender attacks, Attacker
22 defends (21 trials); DAMD - Defender attacks, Midfielder defends (18 trials); MAAD -
23 Midfielder attacks, Attacker defends (18 trials); MADD - Midfielder attacks, Defender
24 defends (18 trials)). Thresholds for effect sizes statistics were trivial (0 to 0.19); small
25 (0.2 to 0.59); moderate (0.6 to 1.19); large (1.2 to 1.99); and very large (≥ 2.0)
26 (direction of observed effects were represented by – ive and + ive). Differences in
27 means for both pairs of scenarios were also expressed in percentage units with 90%
28 confidence intervals (CI) (Hopkins et al., 2009). The relationships between values of
29 relative distance and relative angles were analysed using Pearson's Product Moment
30 Correlation using SPSS 22.0 software (IBM SPSS inc., Chicago, USA).

31

32 3. Results

33 3.1. The effects of field zones

1 Analysis of relative distance values between players and the goal revealed main
2 effects for field zones: Left-Middle ($d = -1.22$ (90%CI: -1.62 to -0.83), moderate -ive),
3 Left-Right ($d = -0.75$ (90%CI: -1.13 to -0.37), small -ive), and Right-Middle ($d = 0.49$
4 (90%CI: 0.11 to 0.87), trivial). Generally, the left zone showed lower relative distance
5 values between players and the goal than the other two zones, with the middle zone
6 revealing the higher values. In the left zone, the relative distance decrease from values
7 around 5m to 1.3m. In the middle and right zones, relative distance started at values
8 near 5.5 m and decreased in the middle to values around 2.5 m and on the right to
9 values near 1.7 m (See Figure 2, left panel).

10 Analysis of values of the relative angle between goal, defender and attacker
11 revealed main effects for field zones: Left-Middle ($d = -6.12$ (90%CI: -6.98 to -5.25),
12 very large -ive), Right-Middle ($d = -5.67$ (90%CI: 4.84 to 6.51), very large -ive, and
13 Left-Right ($d = -0.04$ (90%CI: -0.4 to 0.33), unclear). Generally, higher values of
14 relative angle were observed in the middle zone, than in the left or right zones. In the
15 middle zone angle values were near 180° and in the left and right zones angle values
16 were near 130° to 140°. Interestingly, at the end of the trial in the left zone, an increase
17 in relative angle values to nearer 150° was observed. In the right zone, relative angle
18 values were maintained nearer to 135° (See Figure 2, right panel).

19 Analysis of relationships between values of relative distance and relative angle
20 for each field zone revealed interesting effects. There was a strong negative correlation
21 between the two variables in the left ($r = -.935$, $p < 0.001$) and right zone ($r = -.992$,
22 $p < 0.001$) and a strong positive correlation in the middle zone ($r = .963$, $p < 0.001$).

23
24
25 ***** Insert Figure 2 near here *****

26 27 3.2. The effects of player roles

28 Analysis of relative distance values between players and the goal showed small
29 effects for differences in player roles between DAAD-AADD ($d = -0.6$ (90%CI: -0.08
30 to -1.09), small -ive), DAAD-AAMD ($d = -0.99$ (90%CI: -0.47 to -1.53), small -ive),
31 and DAAD-DAMD ($d = -0.74$ (90%CI: -1.29 to -0.18), small -ive), DAAD-MAAD ($d =$
32 -0.6 (90%CI: -1.17 to -0.02), small -ive). In general, patterns of play of defenders as
33 attackers and attackers as defenders, compared to other roles, revealed lower values of
34 relative distance at the end of the trials (See Figure 3, left panel).

1 Analysis of relative angle between goal, defender and attacker player revealed
2 unclear effects of player role (See Figure 3, right panel).

3 Analysis of relationships between values of relative distance and relative angle for each
4 dyad revealed a strong negative correlation between the two variables, AADD ($r = -$
5 $.860, p < 0.001$); AAMD ($r = -.866, p < 0.001$); DAA ($r = -.697, p < 0.05$); DAMD ($r = -$
6 $.975, p < 0.001$); MAAD ($r = -.915, p < 0.001$); MADD ($r = -.899, p < 0.001$). Interestingly,
7 the weakest correlations were observed between defenders as attackers and attackers as
8 defenders, in line with previous research findings.

9
10 ***** Insert Figure 3 near here *****

11 12 4. Discussion

13 In this study, we sought to examine the interpersonal patterns of coordination
14 that sustained decision-making of participants in 1vs1 sub-phases in football at different
15 field locations near the goal (left-, middle- and right-zones). Also, the effect of players'
16 roles (i.e., attackers, midfielders and defenders) on interpersonal patterns of
17 coordination in 1-vs-1 sub-phases in football was analysed.

18 In line with previous research, the results clearly confirmed an effect of field
19 locations on emergent interpersonal patterns of coordination between an attacker and
20 defender in 1-vs-1 sub-phases (Headrick et al., 2011). Headrick et al. (2011) showed
21 how proximity-to-goal constrained values of defender to ball distance. Our results
22 revealed how variations in field locations near the goal (left-, middle- and right-zones)
23 constrained interpersonal patterns of coordination between attackers and defenders,
24 particularly the relative distance and relative angle values that emerged between them
25 and the goal. In line with other previous studies, our results highlighted relative position
26 of the goal as a key informational variable that sustained participants' behaviours for
27 dribbling and shooting (Travassos et al., 2011; Vilar et al., 2012). Changes in the value
28 of the informational variable 'angle to goal' constrained the dynamics of the 1vs1 dyad,
29 with clear implications for the interpersonal relations that participants explored to be
30 successful, namely the distances and angles between them. Additionally, the exploration
31 of possibilities for action in the 1vs1 dyad was constrained by players' main roles
32 according to the relative position on-field. It is likely that the participants' past
33 experiences in a specific performance role may have strongly influenced their

1 tendencies for engaging in interpersonal coordination with other participants under the
2 constraints of competition.

3 4 4.1. The effect of field locations

5 Higher values of relative distance between attackers and defenders were
6 observed in the middle zone, compared to other zones. At the same time, results of
7 relative angle values between players and the goal were also higher (close to 180°) in
8 the middle zone, than in the left and right zones (near 130° to 140°). The relationship
9 between both variables revealed a positive correlation for middle zone in contrast to
10 right and left zones which revealed negative correlations. A possible explanation for
11 such positive correlations, with higher, more stable values of relative distance near to
12 180° and higher distance values in the middle zone might be related to the high number
13 of opportunities for ball dribblers to explore opportunities for shooting at goal. These
14 results are in line with data reported in previous work by Vilar et al. (2012), suggesting
15 that shooting opportunities emerged by attackers promoting a misalignment in their co-
16 positioning with defenders relative to the ball and the goal. In their study defenders
17 sought to maintain 'attacker-defender-goal symmetry' by placing themselves between
18 the goal and the immediate attacker, maintaining a functional distance to intercept the
19 ball or block a possible shot. This was a challenging task in the middle-zone since the
20 actions of the defenders were constrained by greater opportunities for attackers to
21 exploit space and move left, right or through the middle creating an open angle to shoot
22 at goal. Since attackers had more such affordances (opportunities for action) with the
23 ball, defenders were constrained to be more conservative in positioning, typically by
24 increasing the value of their relative distance with the attacker (Headrick et al., 2011).
25 Interestingly, similar behaviours have been observed at a team level after manipulations
26 of the number of goal targets in a practice task (e.g., 3 goals rather than 1 goal to shoot
27 at). Increasing the number of goal targets available for attackers resulted in the
28 defending teams retreating on field and increasing the distance between them and the
29 attacking team (Travassos, Gonçalves, Marcelino, Monteiro, & Sampaio, 2014).
30 Increasing the number of possibilities for action promotes co-adaptations of participants
31 and teams to adopt more conservative interpersonal patterns of coordination,
32 characterized by greater distance values and stability in the spatial
33 equilibrium/symmetry between performers and the goal(s) location (Travassos et al.,
34 2014).

1 We also observed lower values of relative distances in the left, compared to the
2 right zone. Also, an increase in relative angles, at the end of the trial, to values near to
3 150° was noted in the left zone. In the right zone, the relative angle variable maintained
4 values near to 135°. Interestingly, negative correlations were observed between values
5 of relative distances and angles. When the value of relative distance decreased, the
6 result was an increase in the value of relative angle to maintain the alignment between
7 players and the goal. Differences observed in the relative distance and relative angles, at
8 the end of the trials, between participants in the left and right zones can be explained by
9 the fact that all the players were right-footed. This physical characteristic meant that, in
10 the left zone the attackers could attempt to dribble past the defender with the right foot
11 to open up a shooting angle with the goal. In the right zone, dribbling with the right foot
12 tended to close the shooting angle with the goal. Thus, in the left zone, to prevent
13 attackers from using their favoured foot to dribble and open an angle for shooting at
14 goal, defenders sought to minimize interpersonal distances and the relative angle to the
15 goal. The observed increase in relative angle, at the end of the trial, in the left zone, may
16 represent attempts of attackers to dribble, open the angle to goal and shoot with their
17 favoured right foot. In line with the ecological approach and the notion of affordances,
18 this finding suggests that the exploration of possibilities for action is forged on the
19 relation between emergent spatial relations, relative to the capacities (effectivities) of
20 participants to act and achieve specific performance aims (Araújo et al., 2006; Fajen et
21 al., 2009; Paterson et al., 2016). Indeed, the interpersonal patterns of coordination
22 observed were forged on the acquisition of a perception-action coupling between both
23 attackers and defenders, considering their own action capabilities in relation to the
24 determined spatial relations and the proposed task goals (Travassos et al., 2014; van
25 Anzel, Cole, & Peping, 2017). Further research is required to better understand how
26 variations in the specific capacities of sport performers (e.g., foot preference of
27 participants, different levels of expertise, or even different physical capabilities and
28 levels of fatigue) impact on the emergent dynamics of interpersonal patterns of
29 coordination in different games sub-phases.

30 Clearly, implications for the design of practice tasks can be advocated. Attackers
31 and defenders can be exposed to different relative positions to the goal for training
32 dribbling and shooting, with changes in the preferred foot of both attackers and
33 defenders. That personal constraint manipulation will encourage greater exploration of
34 possibilities for action of attackers to shoot when presented with a more open or closed

1 angle to the goal. Such a manipulation may even encourage participants to explore
2 shooting with the non-preferred foot, depending on the affordances offered by
3 information from the positioning of defenders, relative to the goal. Also, for defenders,
4 such a manipulation will help them to improve their defensive positioning, relative to
5 the goal, and also to identify and nullify use of the preferred foot of attackers. This
6 exploration of capabilities for action of other performers, based on some key
7 informational, will allow learners to become more effective and flexible in their
8 behaviours (Button et al., 2013).

10 4.2. The effect of players' roles

11 Due to different technical and tactical abilities facilitating participants'
12 exploration of the performance environment, it was also expected that different patterns
13 of coordination would emerge in the 1-vs-1 sub-phase between participants with
14 different roles in the squad (Gonçalves et al., 2014). Our results revealed that when a
15 defender attacks, and an attacker defends, lower values in interpersonal distance
16 emerged in comparison with other players' role combinations. This finding can be
17 explained by the capability of opponents to perceive affordances (the potential for
18 actions) of other people, as they can do for themselves (Mark, 2007), consequently
19 changing the interpersonal patterns of coordination that sustain performance. Also,
20 lower correlation values were observed between such variables in these player dyadic
21 systems.

22 In fact, in competitive performance environments, defenders typically do not have many
23 opportunities to experience 1-vs-1 opportunities as attackers and vice-versa, changing
24 the exploration of the environment and potential for action when different roles are
25 required (Travassos et al., 2013). Thus, the findings suggest that perception of the
26 individual capabilities of the defenders to dribble and shoot at goal afforded a decrease
27 in the relative distance between them as an option to reduce their possibilities for action
28 (Travassos et al., 2012). Previous research (Vilar et al., 2012), has suggested that, when
29 a ball dribbler was able to shoot and score a goal, he was able to maintain a significantly
30 larger interpersonal distance value between him and a marking defender.

31 In line with an ecological dynamics approach, these findings suggested that
32 participants' actions emerged from perception of information arising continuously from
33 environmental interactions according to current capabilities for action of individuals
34 (Araújo et al., 2006; Davids et al., 2005). Players' roles seem to have an impact on their

1 current capabilities for action. Thus, to improve player performance, early experience of
2 diverse experiences in the contexts of play and in required perception and action
3 capacities instead of specialization (as defenders or attackers) should help learners to
4 improve their adaptability to the different performance contexts to which they are
5 exposed during competition (Davids, Araújo, Correia, & Vilar, 2013).

6 7 5. Conclusions

8 To summarize, these data support the idea that different field locations near the
9 goal (in left-, middle- and right- zone) constrain the interpersonal coordination that
10 sustain 1-vs-1 sub-phases in football. Players' roles also constitute a constraint on the
11 interpersonal coordination for dribbling and shooting. Data implied that players' foot
12 preference can be considered a key constraint to define the action capabilities of
13 attackers to explore the dribbling and shooting. The findings suggest that coaches
14 should manipulate practice task constraints (i.e. design 1-vs-1 sub-phases in different
15 locations on field and manipulating players' foot preferences on participants' dyads) to
16 increase opportunities for the participants to become better attuned to the informational
17 variables that constrain their performance. By manipulating task constraints, such as
18 field location for attacker-defender dyads or individual constraints such as placing right-
19 or left-footed participants in different areas of play, participants may learn how to detect
20 functional information for decision-making in 1-vs-1 sub-phases.

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Figure captions

Figure 1 – Representation of the three areas of play (left, middle, right) with the definition of the starting zone and their location in relation to the goal. α – represents the relative angle between goal, defender and attacker player. DD – represents the distance between defender to the centre of goal. DA – represents the distance between attackers to the centre of goal.

Figure 2 – Mean values and standard deviations of relative distance between attacker and defender to the centre of goal. Left panel - variations on mean relative distance according to field zones. Right panel - variations on mean relative distance according to players' roles.

Figure 3 – Mean values and standard deviations of relative angle between goal, defender and attacker player. Left panel - variations on mean relative angle according to field zones. Right panel - variations on mean relative angle according to players' roles.