

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/331410727>

Dynamics of Xavi Hernández's game: A vectorial study through polar coordinate analysis

Article in *Proceedings of the Institution of Mechanical Engineers Part P Journal of Sports Engineering and Technology* · February 2019

DOI: 10.1177/1754337119830472

CITATIONS

14

READS

2,239

3 authors:



Rubén Maneiro Dios

Universidad Pontificia de Salamanca

62 PUBLICATIONS 476 CITATIONS

[SEE PROFILE](#)



Mario Amatria

Universidad Pontificia de Salamanca

35 PUBLICATIONS 225 CITATIONS

[SEE PROFILE](#)



M Teresa Anguera

University of Barcelona

284 PUBLICATIONS 4,833 CITATIONS

[SEE PROFILE](#)

Some of the authors of this publication are also working on these related projects:



The role of physical activity and sport in the promotion of healthy lifestyle habits: the evaluation of sport behavior using non-intrusive methods [View project](#)



Judo y Discapacidad Visual [View project](#)

Dynamics of Xavi Hernández's game: A vectorial study through polar coordinate analysis

Proc IMechE Part P:
J Sports Engineering and Technology
1–13

© IMechE 2019

Article reuse guidelines:

sagepub.com/journals-permissions

DOI: 10.1177/1754337119830472

journals.sagepub.com/home/pip



Rubén Maneiro¹ , Mario Amatria¹ and M Teresa Anguera²

Abstract

The evolution of soccer over the past 30 years has brought about a faster pace of play and more demanding player dynamics that have led to a paradigm shift in how the game is analyzed. Classic, purely descriptive studies of midfielder performance paint a disjointed picture that is far from the reality of the complex network of relationships and interactions that mark modern-day soccer. The aim of this study was to investigate the relationships established by Xavier “Xavi” Hernández, captain of FC Barcelona and a member of the Spanish national team for many years, during his participation in the final stages of the 2012 UEFA European Football Championship. The authors studied Xavi’s relationship with other players on the pitch, the areas in which his interventions started and ended, his use of technical–tactical skills, and his involvement in set plays. A modified version of a purpose-designed observation instrument was used within an observational methodology study. The data were analyzed by polar coordinate analysis, which is a powerful data reduction technique that reveals significant prospective and retrospective relationships between a focal behavior (Xavi) and other behaviors of interest. The results show that Xavi presents a mutual activation with behaviors from J6 (Iniesta) and J21 (Silva) and significant relationships in attack set-up zones. He is also the most important player in set piece situations, when he uses technical behaviors of control and passing. Studies on tactical performance should analyze all inputs of play and focus on a deep, layered analysis of results to facilitate the work of soccer coaches and educators.

Keywords

Soccer, performance analysis, polar coordinates, case study, observational methodology

Date received: 2 February 2018; accepted: 20 January 2019

Introduction

Given the complex nature of soccer,¹ the scientific community has largely analyzed performance by applying heuristic techniques that break the game down into measurable units. The analysis of specific performance indicators,^{2–4} such as goal-scoring opportunities,⁵ ball possession,^{6,7} set play,^{8,9} and situational¹⁰ play, have helped to achieve a greater understanding of the dynamics of soccer. Soccer players need to master technical and cognitive motor skills,^{11–13} create opportunities that ultimately result in more shots at goal,¹⁴ and continue to exhibit technical and tactical prowess, even in situations of fatigue¹⁵ and limited space.¹⁶

Player interaction is also a basic component of soccer.¹⁷ The ability to execute effective and efficient patterns of play through a combination of cognitive, perceptual, and motor skills is one of the most important aspects of soccer performance.¹¹ Measuring and assessing entropy in relationships between players will add significance to quantitative data, generally

presented alone,^{14,18} and without taking into account on-the-ball play.¹⁹ Contextualizing player movements on the field and levels of activation,²⁰ modeling tactical behaviors,^{21,22} and player coordination,^{23,24} have led to important progress in understanding the intrinsic complexity of soccer.

However, while reductionist research techniques can help to understand technical or situational aspects of play, they do not provide deep insights into tactical performance. In soccer, the whole is greater than the sum of its parts,^{3,7} and it is therefore necessary to gain a deeper, more sophisticated understanding of what

¹Education Faculty, Pontifical University of Salamanca, Salamanca, Spain

²Psychology Faculty, Neurosciences Institute, University of Barcelona, Barcelona, Spain

Corresponding author:

Rubén Maneiro, Education Faculty, Pontifical University of Salamanca, C/ Henry Collet, 52-70, 37007 Salamanca, Spain.

Email: rmaneirodi@upsa.es

occurs in match situations. For this to be possible, it is necessary to advance beyond superficial, quantifiable methods.^{21,25} The emergence of software applications based on global positioning systems²² and powerful analytical techniques, such as polar coordinate analysis,²⁶ has equipped researchers with the means to describe, estimate, and evaluate relationships and interactions that occur during soccer.^{20,21,27}

Player relationships are very much influenced by individual performance and functions, as well as interactions with other players.²⁷ Players' roles vary greatly from one position to the next, as do the indicators used to analyze performance. Whereas shots at goal and goals scored are key performance indicators for strikers such as Lionel Messi and Cristiano Ronaldo,^{12,13} very different indicators are used to analyze the performance of midfield playmakers,^{28–32} such as Xavier "Xavi" Hernández.³³ For many years, Xavi was considered to be one of the best soccer players in the world. He won the International Federation of Football History & Statistics World's Best Playmaker award for 4 years running from 2008 to 2012. As a long-standing member of the Spanish national team, he had an important role in the team's victory in the FIFA 2010 World Cup and the 2008 and 2012 UEFA European Championships.³³ Gaining qualitative insights into his interactions with other players, his use of space and his influence on collective play could help to evaluate his true performance within the Spanish national team. None of these aspects, however, have been studied through an objective lens, nor from the perspective of interactions between players or spontaneous interaction.^{32–34} The aims of this study were to analyze the relationships that Xavi forms with other members of his team and investigate his use of space, technical skills, and tactics.

Method

Design

The authors performed an observational methodology study,³⁵ as observational designs have proven to be one of the most suitable research methods for studying spontaneous interactions between athletes.^{36–39}

The specific observational design employed was P/M/I,³⁶ which stands for Point (intrasessional follow-up), Multidimensional (analysis of multiple dimensions from the observation instrument), and Idiographic (focus on a single player). The observation of play was scientifically rigorous because the events were fully perceivable and the observers had a non-participatory role.

Participants

The observation sample was a convenience sample³⁶ formed by the actions and behaviors of Xavi during his participation as a member of the Spanish national football team in the 2012 UEFA European Championship.

A total of 6861 multi-events have been encoded. The football matches analyzed include matches between Spain–Italy, Spain–Republic of Ireland, Spain–Croatia, Spain–France, Spain–Portugal, and Spain–Italy.

As such, the study can be considered a case study.^{12,13,32,40} The use of intensive case studies has been attracting increasing attention in scientific literature given their informative potential within mixed-methods studies such as this one.^{41,42}

Observation instrument

The observational instrument proposed by Maneiro and Amatria³² (Table 1) was used, proposing behavior J8 (Xavi Hernández) as focal behavior. The division pitch has also been used as shown in Figures 1 and 2 as proposed by Amatria and colleagues.^{32,43}

Data annotation and coding

The data were annotated and coded⁴⁵ using the free software program LINCE (v.1.4).⁴⁶ The interobserver agreement analysis yielded a kappa value of 0.95 (Table 2). The data were concurrent, time-based (type IV) data.⁵⁴

All three authors are experts in observational methodology.

Data analysis

Polar coordinate analysis was developed by Sackett.²⁶ Although this data analysis technique has been analyzed in numerous empirical studies over the decades,⁴⁷ its use in sports sciences is relatively recent⁴⁵ and it is growing, thanks to the potential and flexibility it offers for studies like this one.^{12,13,49–51}

GSEQ 5.1⁵² and HOISAN v. 1.2⁵³ were used for lag sequential analysis and polar coordinate analysis, respectively.

Polar coordinate analysis requires a prior step that involves the application of lag sequential analysis to calculate adjusted residuals.⁵⁴ The aim of lag sequential analysis is to identify significant relationships between a category of interest (e.g. category J8, Xavi Hernández in this study) and other categories (other players, areas of the pitch, etc.). This analysis allows researchers to search for patterns, both prospectively (through positive lags that occur after the category of interest) and retrospectively (through negative lags that occur before the category of interest).

The aim of polar coordinate analysis, by contrast, is to produce a complete interrelational map showing significant associations between categories of interest, known as "focal behaviors," and other categories, known as "conditional behaviors." The strength of the associations is reflected by vectors shown on a vector map. To produce these vector maps, it is necessary to contemplate both prospective and retrospective perspectives and analyze the same number of lags in

Table 1. Observational instrument.

No.	Dimension	Categories: codes and brief description
1	Ball possession	(PO) possession of ball by team being observed, (PC) possession of ball by rival team, (Inobs) unobservable
2	Player	J0 (unidentified player), J1 (Iker Casillas), J2 (Raúl Albiol), J3 (Gerard Piqué), J4 (Javi Martinez), J5 (Juanfran Torres), J6 (Andrés Iniesta), J7 (Pedro Rodríguez), J9 (Fernando Torres), J10 (Cesc Fàbregas), J11 (Álvaro Negredo), J12 (Víctor Valdés), J13 (Juan Mata), J14 (Xabi Alonso), J15 (Sergio Ramos), J16 (Sergio Busquets), J17 (Álvaro Arbeloa), J18 (Jordi Alba), J19 (Fernando Llorente), J20 (Santiago Cazorla), J21 (David Silva), J22 (Jesús Navas), and J23 (Pepe Reina)—and rival players (JR)
3	Move initiation zone	ZI10, ZI20, ZI30, ZI40—safety sector; ZI50, ZI60, ZI70, ZI80—creation sector in own half; ZI51, ZI61, ZI71, ZI81—creation sector in rival's half; ZI90, ZI100, ZI110, ZI120, ZI130—definition sector
4	Move conclusion zone	ZF10, ZF20, ZF30, ZF40—security sector; ZF50, ZF60, ZF70, ZF80—own creation sector half; ZF51, ZF61, ZF71, ZF81—opponent creation sector half; ZF90, ZF100, ZF110, ZF120, ZF130—finishing sector
5	Contact with ball	(C1) single contact with ball and regulatory throw-in/kick-in; (C12) attempt to control the ball with two or more touches resulting in loss of ball; (C2) control of ball (including catching of ball by goalkeeper) followed by a shot—regardless of whether the ball reaches a team member or is recovered by an opponent; (C23) control of ball, followed by dribbling, and loss of ball; (C24) control of ball, followed by dribbling, attempt to go around one or more opponents, and loss of ball; (C3) control of ball, followed by dribbling and shot—regardless of whether the ball reaches a team member or is recovered by an opponent; (C4) control of ball, passing of one or more opponents, and shot—regardless of whether the ball reaches a team member or is recovered by an opponent; (C5) header
6	Game stoppages	GTO (goal by team being observed), GATO (goal against team being observed), FKTO (free kick for team being observed), OTO (offside for team being observed), TITO (throw-in for team being observed), CKTO (corner kick for team being observed), GKTO (goal kick for team being observed), FKATO (free kick against team being observed), OATO (offside against team being observed), TIATO (throw-in against team being observed), CKATO (corner kick against team being observed), GKATO (goal kick against team observed), NK (kick-off/neutral kick), KO (kick-off), EFH (end of first half), EM (end of match), LB (loss of ball), RB (recovery of ball), and OIC (occasional interception with continuation of play)
7	Interceptions	(LB) loss of ball, (RB) recovery of ball, (OIC) occasional interception with continuation of play
8	Move conclusion	(SG) shot resulting in goal, (SI) shot intercepted by opponent other than the goalkeeper, (SBP) shot between the posts not resulting in a goal, (SWP) shot wide of the posts, (SSG) shot saved or cleared by the goalkeeper, (HEG) header ending in a goal, (HIG) header intercepted by opponent other than the goalkeeper, (HBP) header between the posts not resulting in a goal, (HWP) header wide of the posts, (HBG) header blocked or cleared by the goalkeeper

Source: Maneiro and Amatria.³²

The instrument is a combination of a field format and category systems.⁴⁴ The instrument contained eight dimensions, each of which were broken down into a system of exhaustive, mutually exclusive categories.

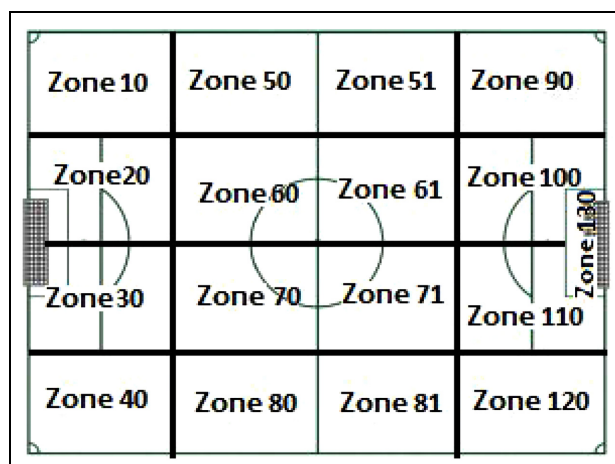
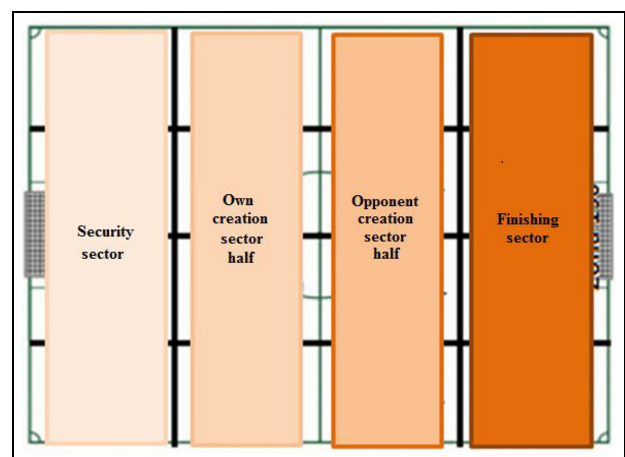
**Figure 1.** Pitch areas.**Figure 2.** Sectors.

Table 2. The interobserver agreement analysis for each criterion.

Dimension	Categories	Kappa	Agreement (%)
Ball possession	PO, PC, Inobs	1.00	100
Player	J0, J1, J2, J3, J4, J5, J6, J7, J8, J9, J10, J11, J12, J13, J14, J15, J16, J17, J18, J19, J20, J21, J22, J23, JR	1.00	100
Move initiation zone	ZI10, ZI20, ZI30, ZI40, ZI50, ZI60, ZI70, ZI80, ZI51, ZI61, ZI71, ZI81, ZI90, ZI100, ZI110, ZI120, ZI130	1.00	100
Move conclusion zone	ZF10, ZF20, ZF30, ZF40, ZF50, ZF60, ZF70, ZF80, ZF51, ZF61, ZF71, ZF81, ZF90, ZF100, ZF110, ZF120, ZF130	0.95	96
Contact with ball	C1, C12, C2, C23, C24, C3, C4, C5	1.00	100
Game stoppages	GTO, GATO, FKTO, OTO, TITO, CKTO, GKTO, FKATO, OATO, TIATO, CKATO, GKATO, NK, KO, EFH, EM, LB, RB, OIC	1.00	100
Interceptions	LB, RB, OIC	1.00	100
Type of shot	SG, SI, SBP, SWP, SSG, HEG, HIG, HBP, HWP, HBG	1.00	100

Table 3. Transformations of vector φ angle according to quadrant.

Z_{sum} sign	Quadrant	Transformation of φ angle
Prospective	Retrospective	
Positive	Positive	I No transformation
Negative	Positive	II $180 - \varphi$
Negative	Negative	III $180 + \varphi$
Positive	Negative	IV $360 - \varphi$

each direction. The adjusted residuals from the lag sequential analysis must first be standardized. To do this, each series of Z values corresponding to the focal behavior and each of the conditional behaviors, whether prospective or retrospective, are reduced through application of the powerful data-reducing Z_{sum} statistic, described by Cochran.⁵⁵ The corresponding formula is shown in equation (1)

$$Z_{sum} = \frac{\sum Z}{\sqrt{n}} \quad (1)$$

where n corresponds to the number of lags and Z corresponds to each of the standardized adjusted residuals. The Z_{sum} statistic is based on the principle that the sum of n independent Z scores (for both prospective and retrospective lags) is normally distributed, with $\mu = 0$ and $\sigma = 1$. As mentioned, the number of prospective and retrospective lags must be identical. The recommended number is five. The outcome is a Z_{sum} statistic for each conditional behavior analyzed. The resulting values will determine the length and angle of the subsequent vectors showing the relationship between each conditional behavior and the focal behavior.

Prospective and retrospective Z_{sum} statistics carry a positive or negative sign, and it is the combination of these signs that determines in which quadrant each conditional behavior is located. Polar coordinate analysis also reveals the nature of the relationship between focal

and conditional behaviors, that is, whether its inhibition, activation, or a combination of these.

The prospective and retrospective Z_{sum} values for each conditional behavior are used to calculate the length shown in equation (2) and angle of the vector showing the relationship with the focal behavior

$$Length = \sqrt{(Z_{sum\ prospective}^2) + (Z_{sum\ retrospective}^2)} \quad (2)$$

For a vector to have a significance level of 0.05, it must have a length greater than 1.96. Once the length and angle have been calculated for each vector, the φ angle must be transformed according to the quadrant in which the vector is located as shown in Table 3.

All the necessary calculations for polar coordinate analysis are performed in the free software program HOISAN,⁵³ which also presents the results as easy-to-interpret vector maps. The quadrant in which the vectors are located determines the nature of the relationship between the focal and conditional behaviors (Figure 3). Quadrant I shows mutual activation between the focal and conditional behaviors, while quadrant III shows mutual inhibition. Quadrant II shows conditional behaviors that activate but are not activated by the focal behavior, while quadrant IV shows conditional behaviors that inhibit but are not inhibited by the focal behavior.

Table 4. Polar coordinate analysis results showing the relationship between Xavi and other players.

Category	Quadrant	Prospective perspective	Retrospective perspective	Radius	Angle (°)
J0 unidentified player	II	−0.12	1.60	1.60	94.33
J1 Iker Casillas	III	−1.68	−2.59	3.09*	237.12
J3 Gerard Piqué	I	0.30	0.18	0.35	30.84
J4 Javi Martínez	IV	1.35	−0.04	1.35	358.10
J6 Andrés Iniesta	I	1.94	1.44	2.42*	36.66
J7 Pedro Rodríguez	III	−0.38	−2.13	2.17*	259.90
J9 Fernando Torres	IV	1.11	−0.52	1.23	334.74
J10 Cesc Fàbregas	III	−0.30	−0.48	0.56	238.33
J11 Álvaro Negredo	II	−1.81	0.18	1.82	174.21
J13 Juan Mata	III	−0.88	−0.14	0.89	189.23
J14 Xabi Alonso	I	0.11	0.95	0.96	83.31
J15 Sergio Ramos	II	−1.97	0.47	2.02*	166.70
J16 Sergio Busquets	I	0.96	1.56	1.83	58.29
J17 Álvaro Arbeloa	IV	1.07	−0.32	1.12	343.52
J18 Jordi Alba	III	−0.70	−0.67	0.96	223.69
J20 Santiago Cazorla	IV	0.15	−0.16	0.22	313.32
J21 David Silva	I	1.88	1.52	2.41*	38.91
J22 Jesús Navas	III	−1.28	−3.18	3.43*	248.05
JR—Rival players	II	−0.13	0.85	0.86	99.02

*Significant association ($Z > 1.96$; $p < 0.05$).

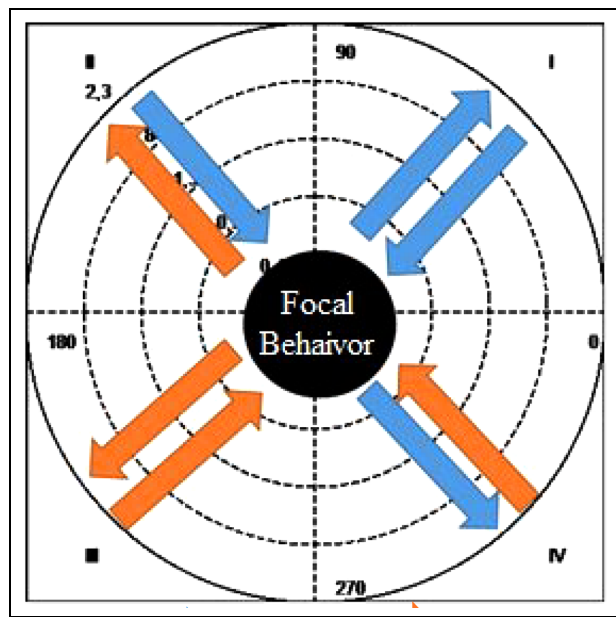


Figure 3. Activating → and → inhibitory relationships between focal and conditional behaviors according to the quadrant in which they are located.

Results

The results have been organized into sections describing Xavi's relationship with six different aspects of play during the competition:

1. Other players on his team;
2. Move initiation zones;
3. Move conclusion zones;
4. Game stoppages and interceptions;
5. Ball contact;
6. Type of shots.

Xavi (code J8) was established as the focal behavior for all the above analyses.

The relationship between Xavi and other players on his team

For this analysis, the relationship was studied between Xavi (J8), defined as the focal behavior or category, and the other players on the Spanish national team—J0 (unidentified player), J1 (Iker Casillas), J2 (Raúl Albiol), J3 (Gerard Piqué), J4 (Javi Martínez), J5 (Juanfran Torres), J6 (Andrés Iniesta), J7 (Pedro Rodríguez), J9 (Fernando Torres), J10 (Cesc Fàbregas), J11 (Álvaro Negredo), J12 (Víctor Valdés), J13 (Juan Mata), J14 (Xabi Alonso), J15 (Sergio Ramos), J16 (Sergio Busquets), J17 (Álvaro Arbeloa), J18 (Jordi Alba), J19 (Fernando Llorente), J20 (Santiago Cazorla), J21 (David Silva), J22 (Jesús Navas), and J23 (Pepe Reina), defined as the conditional behaviors or categories. The association with rival players (JR) was also analyzed. The aim was to determine how Xavi interacted with these players during the championship.

The results in Table 4 and Figure 4 show that both J6 (Andrés Iniesta), with a radius of 2.42 and an angle of 36.66°, and J21 (David Silva), with a radius of 2.41 and an angle of 38.91°, are located in quadrant I, where the focal behavior activates the conditional behavior, both prospectively and retrospectively (mutual activation).

Quadrant II, where the focal behavior inhibits the conditional behavior prospectively and activates it retrospectively, contains J15 (Sergio Ramos), with a radius of 2.02 and an angle of 166.70°.

Quadrant III (mutual inhibition quadrant), in turn, contains J1 (Iker Casillas), J7 (Pedro Rodríguez), and

Table 5. Polar coordinate analysis results showing the relationship between Xavi and move initiation zones.

Category	Quadrant	Prospective perspective	Retrospective perspective	Radius	Angle (°)
ZI10	III	−5.88	−3.58	6.88*	211.31
ZI20	III	−4.05	−2.63	4.83*	212.98
ZI30	III	−3.15	−0.30	3.16*	185.52
ZI40	III	−0.99	−3.09	3.24*	252.24
ZI50	III	−4.76	−0.64	4.80*	187.60
ZI60	II	−3.56	1.82	4.00*	152.98
ZI70	II	−1.89	0.53	1.97*	164.29
ZI80	III	−3.43	−0.29	3.44*	184.85
ZI51	IV	0.79	−0.13	0.80	350.64
ZI61	I	4.07	2.96	5.03*	36.02
ZI71	IV	3.70	−0.74	3.78*	348.66
ZI81	III	−0.07	−1.14	1.15	266.65
ZI90	I	0.31	0.62	0.69	63.43
ZI100	IV	2.92	−0.14	2.92*	357.28
ZI110	I	5.61	1.37	5.78*	13.75
ZI120	I	1.39	0.65	1.53	25.22
ZI130	I	2.40	1.49	2.83*	31.80

*Significant association ($Z > 1.96$; $p < 0.05$).

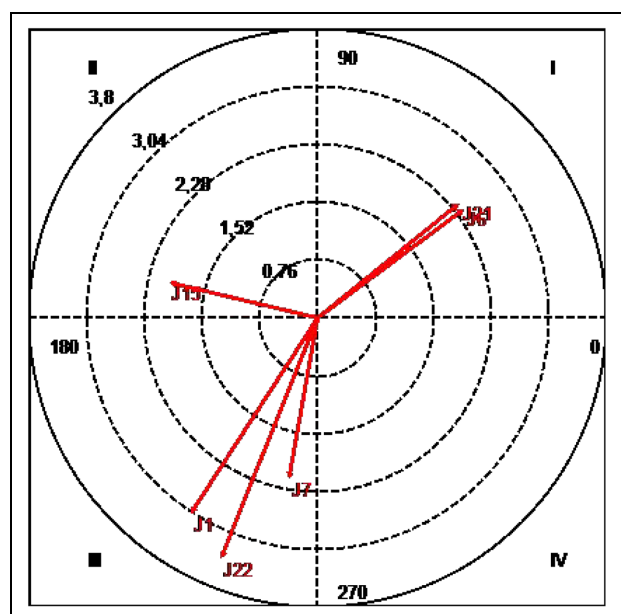


Figure 4. Vector map showing relationships between Xavi and other players.

J22 (Jesús Navas), with respective radii of 3.09, 2.17, and 3.43 and angles of 237.12°, 259.9°, and 248.05°.

The relationship between Xavi and move initiation zones

In this analysis, investigations were conducted on the relationship between Xavi (J8) and the different areas of the pitch where he initiated his actions (ZI10, ZI20, ZI30, ZI40, ZI50, ZI60, ZI70, ZI80, ZI51, ZI61, ZI71, ZI81, ZI90, ZI100, ZI110, ZI120, and ZI130). The aim was to investigate his use of and interaction with space during the course of play.

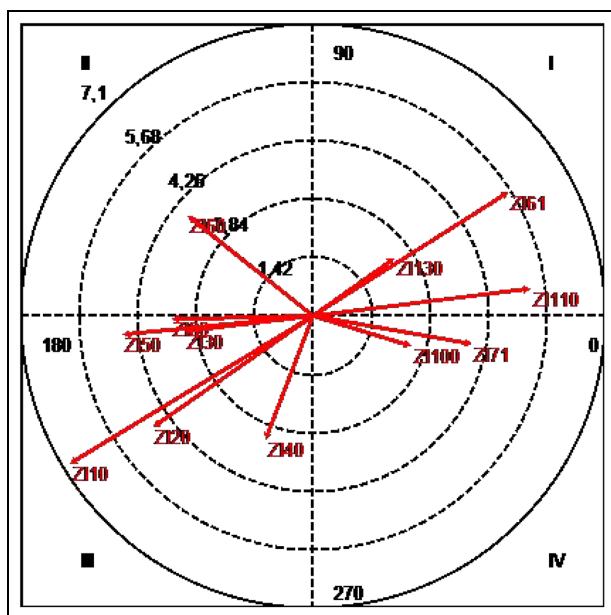


Figure 5. Vector map showing relationships between Xavi and move initiation zones.

The results (Table 5 and Figure 5) show that the mutual activation quadrant I contains ZI61, with a radius of 5.03 and an angle of 36.02°; ZI110, with a radius of 5.78 and an angle of 13.75°; and ZI130, with a radius of 2.83 and an angle of 31.8°.

Quadrant II, where the focal behavior inhibits and is activated by the conditional behaviors, contains the two central areas of the Spanish national team's half: ZI60, with a radius of 4.00 and an angle of 152.98°, and ZI70, with a radius of 1.97 and an angle of 164.29°.

The mutual inhibition quadrant, quadrant III, contains categories ZII0, with a radius of 6.88 and an angle of 211.31°; ZI20, with a radius of 4.83 and an angle of 212.98°; ZI30, with a radius of 3.16 and an angle of

Table 6. Polar coordinate analysis results for the relationship between Xavi and move conclusion zones.

Category	Quadrant	Prospective perspective	Retrospective perspective	Radius	Angle (°)
ZF10	III	-3.95	-3.56	5.32*	222.03
ZF20	III	-3.30	-3.78	5.02*	228.86
ZF30	III	-2.23	-0.87	2.39*	201.38
ZF40	III	-1.62	-3.37	3.74*	244.29
ZF50	III	-4.36	-2.79	5.18*	212.62
ZF60	II	-3.53	3.01	4.64*	139.53
ZF70	II	-2.35	1.51	2.79*	147.23
ZF80	III	-2.40	-0.31	2.42*	187.32
ZF51	IV	1.27	-2.90	3.17*	293.71
ZF61	I	2.46	4.77	5.37*	62.77
ZF71	I	2.59	3.14	4.07*	50.44
ZF81	III	-1.59	-1.67	2.31*	226.49
ZF90	III	-0.18	-0.87	0.89	258.41
ZF100	IV	2.27	-0.77	2.39*	341.26
ZF110	I	5.16	0.82	5.23*	9.06
ZF120	IV	0.69	-0.7	0.98	314.45
ZF130	I	4.48	0.51	4.51*	6.43

*Significant association ($Z > 1.96$; $p < 0.05$).

185.52°; ZI40, with a radius of 3.24 and an angle of 252.24° (all in the safety sector); ZI50, with a radius of 4.80 and an angle of 187.60°; and ZI80, with a radius of 3.44 and an angle of 184.85°.

Finally, ZI71, with a radius of 3.78 and an angle of 348.66°, and ZI100, with a radius of 2.92 and an angle of 357.28°, were located in quadrant IV, where the focal behavior activates, but is not activated by the conditional behaviors.

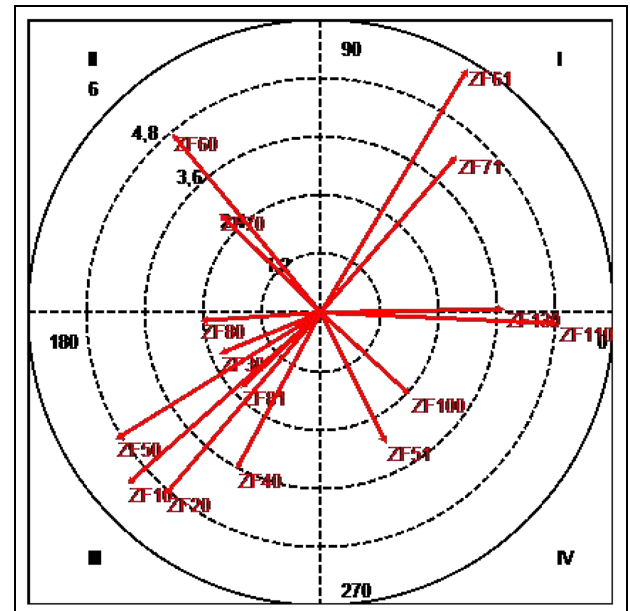
The relationship between Xavi and move conclusion zones

In this analysis, the relationship between Xavi (J8) and the different areas of the pitch in which his interventions started (ZF10, ZF20, ZF30, ZF40, ZF50, ZF60, ZF70, ZF80, ZF51, ZF61, ZF71, ZF81, ZF90, ZF100, ZF110, ZF120, and ZF130) was studied. The aim was to analyze how he interacted with these areas during the Spanish national team's attacks.

The results in Table 6 and Figure 6 show the following categories located in quadrant I (mutual activation): ZF61, with a radius of 5.37 and an angle of 62.77°; ZF71, with a radius of 4.07 and an angle of 50.44°; ZF110, with a radius of 5.23 and an angle of 9.06°; and ZF130, with a radius of 4.51 and an angle of 6.43°.

Quadrant II, which shows conditional behaviors that are inhibited by but do not inhibit the focal behavior, contains the two central areas of the Spanish national team's half: ZF60, with a radius of 4.64 and an angle of 139.53°, and ZF70, with a radius of 2.79 and an angle of 147.23°.

The mutual inhibition quadrant, quadrant III, contains categories ZF10, with a radius of 5.32 and an angle of 222.03°; ZF20, with a radius of 5.02 and an angle of 228.86°; ZF30, with a radius of 2.39 and an angle of 201.38°; ZF40, with a radius of 3.74 and an

**Figure 6.** Vector map showing relationships between Xavi and move conclusion zones.

angle of 244.29° (all in the safety sector); ZF50, with a radius of 5.18 and an angle of 212.62°; ZF80, with a radius of 2.42 and an angle of 187.32°; and ZF81, with a radius of 2.31 and an angle of 226.49°.

Finally, quadrant IV, which shows conditional behaviors that are activated by but do not activate the focal behavior, contains ZF51, with a radius of 3.17 and an angle of 293.71°, and ZF100, with a radius of 2.39 and an angle of 341.26°.

The relationship between Xavi and game stoppages and interceptions

For this analysis, the relationship between Xavi (J8) and different aspects related to game stoppages and

Table 7. Polar coordinate analysis results showing the relationship between Xavi and game situations (stoppages and interceptions).

Category	Quadrant	Prospective perspective	Retrospective perspective	Radius	Angle (°)
GTO	III	-0.51	-0.41	0.65	219.15
FKTO	II	-2.26	4.53	5.06*	116.57
OTO	III	-1.06	-1.22	1.62	228.81
TITO	III	-2.52	-3.73	4.50*	235.90
CKTO	II	-0.19	10.09	10.10*	91.09
GKTO	III	-0.03	-2.26	2.26*	269.32
FKATO	IV	0.52	-0.52	0.74	314.75
OATO	IV	1.17	-1.05	1.57	318.11
TIATO	III	-1.09	-0.64	1.26	210.48
CKATO	IV	3.90	-0.76	3.97*	348.97
NK	III	-1.22	-1.07	1.62	221.20
KO	IV	0.30	-1.72	1.75	279.87
EFH	II	-1.27	0.06	1.27	177.18
EM	IV	2.56	-0.78	2.68*	342.99
LB	III	-0.57	-2.39	2.46*	256.54
RB	IV	1.23	-1.31	1.80	313.19
OIC	I	1.85	2.50	3.11*	53.48

*Significant association ($Z > 1.96$; $p < 0.05$)

Following statistical criteria, results that do not provide information are removed from the results (GATO and GKATO).

interceptions (GTO, GATO, FKTO, OTO, TITO, CKTO, GKTO, FKATO, OATO, TIATO, CKATO, GKATO, NK, KO, EFH, EM, LB, RB, and OIC) was analyzed. The aim was to investigate Xavi's involvement in these situations.

Quadrant I, where the focal behavior activates and is activated by the presence of conditional behaviors, contains the category OIC with a radius of 3.11 and an angle of 53.48° (Table 7 and Figure 7).

Quadrant II, which shows conditional behaviors that are inhibited by but do not inhibit the focal behavior, contains FKTO with a radius of 5.06 and an angle of 116.57°, and CKTO with a radius of 10.10 and an angle of 91.09°.

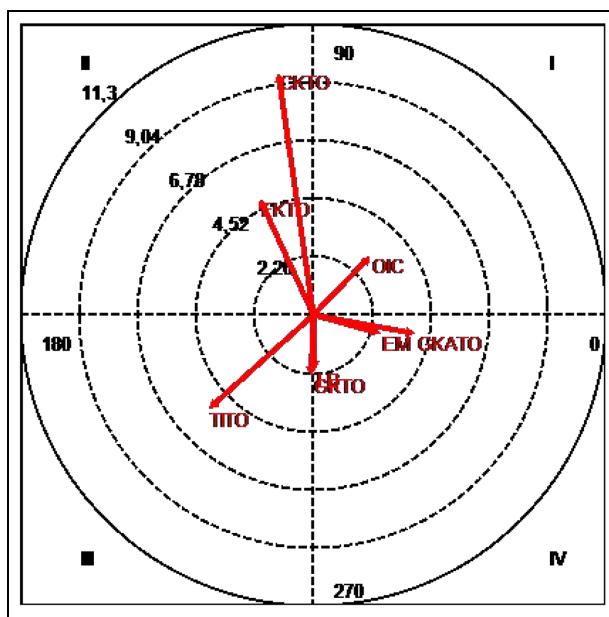
Quadrant III, the mutual inhibition quadrant, contains TITO with a radius of 4.50 and an angle of 235.90°; GKTO with a radius of 2.26 and an angle of 269.32°; and LB with a radius of 2.46 and an angle of 256.54°.

Finally, quadrant IV, which shows conditional behaviors that are activated by but do not activate the focal behavior, contains CKATO with a radius of 3.97 and an angle of 348.97°, and EM with a radius of 2.68 and an angle of 342.99°.

The relationship between Xavi and ball contact

For this analysis, the relationship was studied between Xavi (J8) and the different categories in the ball contact dimension (C1, C12, C2, C23, C24, C3, C4, and C5). The aim was to investigate the player's use of technical skills.

Quadrant I, where the focal and conditional behaviors activate each other, contains the category C2, with a radius of 3.19 and an angle of 44.20° (Table 8 and Figure 8).

**Figure 7.** Vector map showing the relationships between Xavi and game situations (interruptions and interceptions).

Quadrant III, which shows mutual inhibition, contains the conditional behaviors C1, with a radius of 2.89 and an angle of 216.00°, and C5, with a radius of 2.11 and an angle of 239.24°.

The relationship between Xavi and type of shots

For this analysis, the relationship was studied between Xavi (J8) and the different categories in the type of shot dimension: SG, SI, SBP, SWP, SSG, HEG, HIG, HBP, HWP, and HBG. The aim was to analyze Xavi's intervention in shots.

Quadrant IV, where the focal behavior activates and is inhibited by the presence of the conditional behavior,

Table 8. Polar coordinate analysis results showing the relationship between Xavi and ball contact.

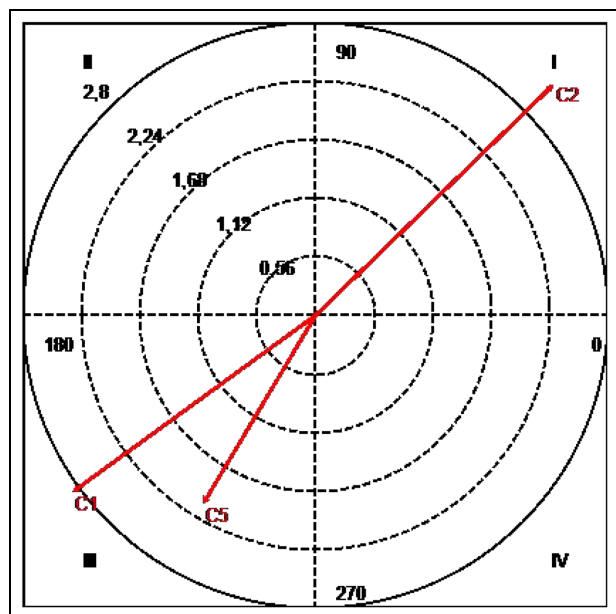
Category	Quadrant	Prospective perspective	Retrospective perspective	Radius	Angle (°)
C1	III	−2.34	−1.70	2.89*	216.00
C12	III	−1.14	−1.47	1.86	232.03
C2	I	2.29	2.22	3.19*	44.20
C23	III	−1.12	−0.33	1.17	196.43
C24	III	−0.40	−0.48	0.63	230.51
C3	I	1.27	0.44	1.34	19.10
C4	III	−0.57	−0.20	0.61	198.97
C5	III	−1.08	−1.81	2.11*	239.24

*Significant association ($Z > 1.96$; $p < 0.05$).

Table 9. Polar coordinate analysis results showing the relationship between Xavi and type of shot.

Category	Quadrant	Prospective perspective	Retrospective perspective	Radius	Angle (°)
SG	III	−0.75	−0.18	0.77	193.47
SI	II	−0.10	1.81	1.81	93.25
SBP	II	−0.72	1.02	1.24	125.18
SWP	IV	0.96	−2.25	2.44*	293.09
HEG	III	−0.34	−1.20	1.24	254.37
HIG	II	−0.57	1.48	1.59	110.99
HWP	IV	0.92	−0.25	0.95	345.05
HBP	III	−0.06	−0.53	0.53	263.23

*Significant association ($Z > 1.96$; $p < 0.05$).

**Figure 8.** Vector map showing relationships between Xavi and type of ball contact.

contains the category SWP with a radius of 2.44 and an angle of 293.09° (Table 9 and Figure 9).

Discussion

In this study, polar coordinate analysis, a powerful analytical technique that reduces large volumes of data to manageable amounts without losing key

information, was used to analyze how Xavi interacts with other members on the Spanish national team and determine how he contributes to the collective effort through his use of space and technical–tactical skills. The analysis produced a series of polar coordinate vector maps that show significant prospective and retrospective relationships between Xavi and the different categories from the ad hoc instrument.

Xavi's role on the Spanish national soccer team has been studied very little by the scientific community, with work to date focused largely on the overall performance of the team, rather than on a detailed analysis of Xavi's proficiency or interactions.^{33,51} As has been pointed out by numerous authors, understanding how different members of a team interact is essential for understanding their performance as a whole.^{12,13,32}

In the rest of this discussion, the results are analyzed in the same order as they appear in the results section and each section is concluded with some practical recommendations for consideration by coaches.

Xavi's relationship with the other players on his team

The results show mutual activation between Xavi and both Iniesta (J6) and Silva (J21). Although previous work has identified Xavi as the most technically accomplished player in the 2008 European Cup,³³ it is perfectly conceivable that Xavi also makes tactical decisions by teaming up with other playmakers with superior technical and tactical prowess to overcome rivals. The intensity of the relationships with J6 and

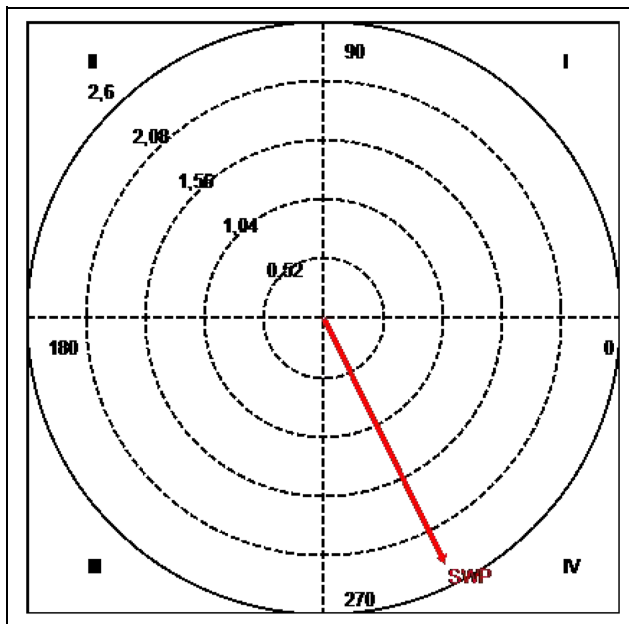


Figure 9. Vector map showing relationships between Xavi and type of shot.

J21 in quadrant I (respective radii of 2.42 and 2.41) suggests that Xavi advances the ball up the pitch mostly through short passes to Iniesta and Silva. These players employ space strategically by moving in from the left and right wings to team up with players in the center areas and create optimal playmaking situations by outnumbering the opposition. In addition, the presence of Ramos (J15) had an activating effect on Xavi. Ramos is a central defender and as such has an important playmaking role, as players in this position are responsible for delivering the ball to the next line of attack under the best possible circumstances.

This novel tactical arrangement involves constant movement by some of the most talented players on the team seeking to create and occupy space, regardless of their original positions, thereby creating opportunities for on-the-ball play by key players. To defend against such tactics, coaches should aim to place more defenders in the central areas of the pitch to impede these continuous interactions.

Xavi's relationship with move initiation and conclusion zones

As shown in the polar coordinate map in Figure 5, a mutually activating relationship existed between Xavi and ZI61, ZI110, and ZI130, which are key areas for launching and ending attacks. This finding indicates two things. First, Xavi prioritizes the delivery of the ball to specific areas (ZI61, ZI110, and ZI130). Second, he dominates actions that are typically seen in strikers, such as shots at goal. Although Xavi is a playmaking midfielder, the findings show a strong relationship (radius of 5.78) with move conclusions. These findings

indicate that Xavi is a highly versatile, unpredictable player who is effective not only at setting up attacks but also at developing and finishing them.

The activating effect of Xavi on category ZF51 (with a radius of 3.17) observed in quadrant IV is also interesting as it is directly related to the use of space and shows that Xavi activated play in the wing. By moving the ball wide, Xavi extended the area in which he had to set up an attack, thus gaining more space and time to be creative and make decisions, while opening up new opportunities in the wings. Grund⁵⁶ showed that teams who use these tactics increase their goal-scoring opportunities by 8%.

Categories ZI60 and ZI70 in quadrant II activated the presence of Xavi, which is consistent with previous observations, and are also directly related to the activation of Xavi by Ramos in the quadrant showing the relationships between Xavi and his teammates. When the ball is in possession of the backline players, Xavi activates his movements in the center of the defensive midfield, seeking to receive the ball and continue the attack by moving it up to the next line in the creation sector of the rival team. Xavi also activates the presence of categories ZI71 and ZI100 in quadrant IV (radii of 3.78 and 2.92, respectively). This activation is related to interventions ending in a shot, indicating Xavi's role in acting as the direct link between defense and attack. The findings show that Xavi is instrumental in facilitating the close relationship between the Spanish national team's attacking and defending lines. Previous research has highlighted the strong organizational setup of the Spanish national team.⁵⁷

Coaches should pay close attention to areas of the pitch in which highly skilled midfield players like Xavi initiate their actions (generally the midfield line). Preventing play from progressing past these initial attack set-up zones will logically prevent the ball from reaching the move conclusion zones and increase defensive performance.

Xavi's relationship with game stoppages and interceptions

The presence of FKTO (free kicks) and CKTO (corner kicks) in quadrant II (Figure 7) suggests a direct association between Xavi and set plays executed with the foot. In addition, the association between Xavi and TITO (sideline throw-ins) was mutually inhibitory. Set plays are particularly advantageous in attacking situations as they allow players to execute strategies aimed ultimately at reaching the goal. These actions have been reported in the literature as very important from an offensive perspective.^{8,58,59} The findings of this study show that Xavi is not only the most important contributor to dynamic attack but also has a key role in set plays. Recent studies have corroborated the importance of midfield players in dynamic and in set piece situations.³² Although surrounded by high contextual

uncertainty, set plays provide their executor with the time and space they generally lack during the normal course of play.⁶⁰ Set-play takers are in the privileged position of being able to choose from a range of tactics to set up the next stage of attack. Examples are the relationship between CKTO (corner kicks) and Ramos (J15) and Piqué (J3), who are both expert corner kickers. Wallace and Norton¹⁴ use the term “set piece specialists” to refer to players with particular skills or abilities in events such as free kicks or throw-ins. The data indicate that Xavi can also be considered a set piece specialist.

At a practical level, soccer coaches should work on avoiding situations that award the opposition set plays such as corner kicks or free kicks, opting instead for tactics such as pressure, dissuasion, and timing.

Xavi's relationship with ball contact

Passing is the best option for establishing tactical relationships between players. In this study, a mutually activating relationship occurred between Xavi and the category C2 (ball control + shot). Previous work has shown that teams that use this tactic scored more goals.⁶⁰ Player interactions maximize potential at both an individual and collective level.⁶¹ Considering the findings, Xavi can perhaps be considered a contextual player, whose priority is to interact with other players using ball control and passes, rather than sophisticated dribbling and skill moves. Xavi depends on these interactions to achieve objectives of varying complexity that are ultimately related to setting up an effective attack.

Coaches should design defensive strategies aimed at preventing players like Xavi from intervening in different sequences of play. Tactics such as outnumbering and tight marking should help to dissuade players from attempting C2 (ball control + pass).

Xavi and his relationship with type of shots

The findings show that Xavi is a highly versatile player who masters many aspects of the game. The activation of SWP (shot wide of the posts) with a radius of 2.44 shows that Xavi also takes shots. This is particularly interesting, as it shows that, apart from technical prowess, he has a wide sphere of influence extending to different areas of the pitch. His profile, thus, would appear to differ substantially from that of a typical midfielder.³¹ From an overall defensive perspective, coaches should be aware of this wide sphere of action when designing tactics to impede interventions.⁶²

Finally, in this study, the different relationships that Xavi formed with other members of his team were analyzed and his use of spatial, technical, and tactical skills was investigated. In the discussion of results, aspects of practical interest to soccer coaches were highlighted. Based on the significant associations observed between Xavi and the different categories in the observation

instrument, several aspects that characterize Xavi's style of play were identified. As a playmaker, he forms significant relationships with highly tactical and creative players, such as Silva, Iniesta, and Ramos. These relationships are established through ball control and passes and are aimed at advancing the ball up the pitch in the most favorable circumstances possible. Apart from his prowess as a playmaker in the midfield area, Xavi is also active in goal-scoring areas of the pitch, where he contributes to the attack through interactions and shots at goal.³² Finally, he is active both in dynamic and in set piece situations and is responsible for putting the ball back into play following stoppages. The findings demonstrate that observational methodology, especially polar coordinate, offers a means of objectively and empirically studying spontaneous behavior during the natural course of play. Future studies should study other players who have an influential role on their teams and offer practical recommendations for application in real-life situations.

Limitations

As for the limitations of this study, the degree of generalization or the external validity of the results obtained was based on the selected behaviors of only Xavi Hernández with the national team. Additional research would need to examine the player's behavior with his team, Futbol Club Barcelona. Another limitation concerns the number of games analyzed. Although the player's performance was analyzed during one of the most important international championships, there is no doubt that a greater number of matches and competitions would provide considerably more data to validate the findings of this study.


Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

This work is supported by two Spanish government projects (Ministerio de Economía y Competitividad)—*La actividad física y el deporte como potenciadores del estilo de vida saludable: Evaluación del comportamiento deportivo desde metodologías no intrusivas* (grant number DEP2015-66069-P, MINECO/FEDER, UE) and *Avances metodológicos y tecnológicos en el estudio observacional del comportamiento deportivo* (PSI2015-71947-REDP, MINECO/FEDER, UE)—and by the Generalitat de Catalunya Research Group, GRUP DE RECERCA I INNOVACIÓ EN DISSENYS (GRID). *Tecnologia i aplicació multimedia i digital als dissenys observacionals* (grant number 2017 SGR 1405).

ORCID iD

Rubén Maneiro  <https://orcid.org/0000-0002-2215-9720>

References

- McGarry T, Anderson D, Wallace S, et al. Sport competition as a dynamical self-organizing system. *J Sport Sci* 2002; 20(10): 771–781.
- Hughes M and Bartlett R. The use of performance indicators in performance analysis. *J Sport Sci* 2002; 20(10): 739–754.
- Mackenzie R and Cushion C. Performance analysis in football: a critical review and implications for future research. *J Sport Sci* 2012; 12: 1–38.
- Lago-Peñas C and Lago-Ballesteros J. Game location and team quality effects on performance profiles in professional soccer. *J Sport Sci Med* 2011; 10(3): 465–471.
- Tenga A, Ronglan L and Bahr R. Measuring the effectiveness of offensive match-play in professional soccer. *Eur J Sport Sci* 2010; 10(4): 269–277.
- Collet C. The possession game? A comparative analysis of ball retention and team success in European and international football, 2007–2010. *J Sports Sci* 2013; 31(2): 123–136.
- Casal C, Maneiro R, Losada J, et al. Possession zone as a performance indicator in football. The game of the best teams. *Front Psychol* 2017; 8: 1176.
- Casal C, Maneiro R, Ardá T, et al. Analysis of corner kick success in elite football. *Int J Perform Anal Sport* 2015; 15(2): 430–451.
- Liu H, Yi Q, Giménez V, et al. Performance profiles of football teams in the UEFA Champions League considering situational efficiency. *Int J Perform Anal Sport* 2015; 15(1): 371–390.
- Taylor JB, Mellalieu SD, James N, et al. The influence of match location, quality of opposition, and match status on technical performance in professional association football. *J Sport Sci* 2008; 26: 885–895.
- Ali A. Measuring soccer skill performance: a review. *Scand J Med Sci Sports* 2011; 21(2): 170–183.
- Castañer M, Barreira D, Camerino O, et al. Goal scoring in soccer: a polar coordinate analysis of motor skills used by Lionel Messi. *Front Psychol* 2016; 7: 806.
- Castañer M, Barreira D, Camerino O, et al. Mastery in goal scoring, T-pattern detection, and polar coordinate analysis of motor skills used by Lionel Messi and Cristiano Ronaldo. *Front Psychol* 2017; 8: 741.
- Wallace JL and Norton KI. Evolution of World Cup soccer final games 1966–2010: game structure speed and play patterns. *J Sport Sci Med* 2014; 17(2): 233–238.
- Méndez-Villanueva A, Buchheit M, Simpson B, et al. Match play intensity distribution in youth soccer. *Int J Sport Med* 2013; 34: 101–110.
- Aguiar M, Gonçalves B, Botelho G, et al. Footballers' movement behavior during 2-, 3-, 4- and 5-a side small-sided games. *J Sport Sci* 2015; 33(12): 1259–1266.
- Grehaighe JF, Bouthier D and David B. Dynamic-system analysis of opponent relationships in collective actions in soccer. *J Sport Sci* 1997; 15(2): 137–149.
- Svensson M and Drust B. Testing soccer players. *J Sport Sci* 2005; 23: 601–618.
- Di Salvo V, Baron R, Tschann H, et al. Performance characteristics according to playing position in elite soccer. *Int J Sport Med* 2007; 28(3): 222–227.
- Perea A, Castellano J, Alday L, et al. Analysis of behaviour in sports through polar coordinate analysis with MATLAB®. *Qual Quant* 2012; 46(4): 1249–1260.
- Lago-Peñas C and Anguera MT. Use of the polar coordinates technique to study interactions among professional soccer players. *Rev Port Ciênc Desporto* 2002; 2(4): 21–40.
- Sampaio J and Maças V. Measuring tactical behaviour in football. *Int J Sport Med* 2012; 33(5): 395–401.
- Liu H, Gómez MA, Gonçalves B, et al. Technical performance and match-to-match variation in elite football teams. *J Sport Sci* 2015; 34: 509–518.
- McLean S, Salmon PM, Gorman AD, et al. What's in a game? A systems approach to enhancing performance analysis in football. *PLoS ONE* 2017; 12(2): e0172565.
- Anguera MT, Camerino O, Castañer M, et al. Métodos mixtos en actividad física y deporte [Mixed methods in research into physical activity and sport]. *Rev Psicol Dep* 2014; 23: 123–130.
- Sackett GP. Lag sequential analysis as a data reduction technique in social interaction research. In: Sawin DB, Hawkins RC, Walker LO, et al. (eds) *Exceptional infant. Psychosocial risks in infant-environment transactions*. New York: Brunner/Mazel, 1980, pp.300–340.
- Castellano J and Hernández-Mendo A. El análisis de coordenadas polares para la estimación de relaciones en la interacción motriz en fútbol [Polar coordinate analysis for estimating motor interaction relationships in soccer]. *Psicothema* 2003; 15(4): 569–574.
- Carling C, Espié V, Le Gall F, et al. Work-rate of substitutes in elite soccer: a preliminary study. *J Sci Med Sport* 2010; 13(2): 253–255.
- Clemente F, Martins F, Wong D, et al. Midfielder as the prominent participant in the building attack: a network analysis of national teams in FIFA World Cup 2014. *Int J Perform Anal Sport* 2015; 15(2): 704–722.
- Fransen K, Haslam S, Mallett C, et al. Leading from the centre: a comprehensive examination of the relationship between central playing positions and leadership in sport. *PLoS ONE* 2016; 11(12): e0168150.
- Thelwell C, Greenlees I and Weston N. Using psychological skills training to develop soccer performance. *J Appl Sport Psycho* 2016; 18(3): 254–270.
- Maneiro R and Amatria M. Polar coordinate analysis of relationships with teammates, areas of the pitch, and dynamic play in soccer: a study of Xabi Alonso. *Front Psychol* 2018; 9: 389.
- Duch J, Waitzman JS and Amaral L. Quantifying the performance of individual players in a team activity. *PLoS ONE* 2010; 5(6): e10937.
- Memmert D, Lemmink KA and Sampaio J. Current approaches to tactical performance analyses in soccer using position data. *Sports Med* 2017; 47(1): 1–10.
- Anguera MT. Observational typology. *Qual Quant* 1979; 13(6): 449–484.
- Anguera MT, Blanco-Villaseñor A, Hernández-Mendo A, et al. Diseños observacionales: ajuste y aplicación en psicología del deporte [Observational designs: their suitability and application in sport psychology]. *Cuad Psicol Dep* 2011; 11(2): 63–76.
- Sánchez-Algarra P and Anguera MT. Qualitative/quantitative integration in the inductive observational study of

- interactive behaviour: impact of recording and coding predominating perspectives. *Qual Quant* 2013; 47(2): 1237–1257.
38. Camerino O, Castañer M and Anguera MT. *Mixed methods research in the movement sciences: case studies in sport, physical education and dance*. London: Routledge, 2012.
 39. Anguera MT, Camerino O, Castañer M, et al. The specificity of observational studies in physical activity and sports sciences: moving forward in mixed methods research and proposals for achieving quantitative and qualitative symmetry. *Front Psychol* 2017; 8: 2196.
 40. Yin RK. *Case study research: design and methods*. 5th ed. Los Angeles, CA: SAGE, 2014.
 41. Maxwell JA, Chmiel M and Rogers SE. Designing integration in multimethod and mixed methods research. In: Hesse-Biber SN and Johnson RB (eds) *The Oxford handbook of multimethod and mixed methods research inquiry*. Oxford: Oxford University Press, 2015.
 42. O’Cathain A, Murphy E and Nicholl J. Three techniques for integrating data in mixed methods studies. *Brit Med J* 2010; 341: c4587.
 43. Amatria M, Lapresa D, Arana J, et al. Optimization of game formats in U-10 soccer using logistic regression analysis. *J Hum Kinet* 2016; 24: 163–171.
 44. Anguera MT, Magnusson MS and Jonsson GK. Instrumentos no estándar [Non-standard instruments]. *Avan Med* 2007; 5(1): 63–82.
 45. Anguera MT and Hernández-Mendo A. Técnicas de análisis en estudios observacionales en ciencias del deporte [Data analysis techniques in observational studies in sport sciences]. *Cuad Psicol* 2015; 15(1): 13–30.
 46. Gabin B, Camerino O, Anguera MT, et al. Multiplatform sport analysis software. *Procedia Soc Behav Sci* 2012; 46: 4692–4694.
 47. Gorospe G and Anguera MT. Modificación de la técnica clásica de coordenadas polares mediante un desarrollo distinto de la retrospectividad: Aplicación al tenis [Modification of the classic polar coordinate technique through a distinct application of retrospectivity using an example from tennis]. *Psicothema* 2000; 12(2): 279–282.
 48. Hernández-Mendo A, Castellano J, Camerino O, et al. Programas informáticos de registro, control de calidad del dato, y análisis de datos [Observational software, data quality and data analysis]. *Rev Psicol Dep* 2014; 23(1): 111–121.
 49. Aragón S, Lapresa D, Arana J, et al. An example of the informative potential of polar coordinate analysis: sprint tactics in elite 1500 m track events. *Meas Phys Educ Exerc Sci* 2017; 16(3): 279–286.
 50. López J, Valero A, Anguera MT, et al. Disruptive behavior among elementary students in physical education. *Springerplus* 2016; 5: 1154.
 51. Robles F, Castellano J, Perea A, et al. Spatial strategy used by the world champion in South Africa 2010. In: Nunome H, Drust B and Dawson B (eds) *Science and football VII: the proceedings of the seventh world congress on science and football*. London: Routledge, 2013, p.161.
 52. Bakeman R and Quera V. *Analyzing interaction: sequential analysis with SDIS and GSEQ*. Cambridge: Cambridge University Press, 1995.
 53. Hernández-Mendo A, López-López JA, Castellano J, et al. Hoisan 1.2: Programa informático para uso en metodología observacional [Hoisan 1.2: program for use in observational methodology]. *Cuad Psicol Dep* 2012; 12(1): 55–78.
 54. Bakeman R. Untangling streams of behavior: sequential analysis of observation data. In: Sackett GP (ed.) *Observing behavior: data collection and analysis methods*. Baltimore, MD: University of Park Press, 1978.
 55. Cochran WG. Some methods for strengthening the common test. *Biometrics* 1954; 10: 417–451.
 56. Grund T. Network structure and team performance: the case of English Premier League soccer teams. *Soc Networks* 2012; 34(4): 682–690.
 57. Moura F, Santana J, Vieira N, et al. Analysis of soccer players’ positional variability during the 2012 UEFA European championship: a case Study. *J Hum Kinet* 2015; 47: 225–236.
 58. Maneiro R, Losada J, Casal C, et al. Multivariate analysis of indirect free kick in the FIFA World Cup 2014. *Ann Psychol* 2017; 33(3): 461–470.
 59. Maneiro R, Ardá T, Rial A, et al. El saque de esquina como indicador de rendimiento en fútbol. Una revisión empírica [The corner kick as an indicator of soccer performance. An empirical review]. *Rev Cien Deport* 2017; 13(3): 273–286.
 60. Maneiro R. *Análisis de las acciones a balón parado en el fútbol de alto nivel: saques de esquina y tiros libres indirectos. Un intento de identificación de variables explicativas* [Analysis of set plays in elite soccer: corner kicks and indirect free kicks: an attempt to identify predictor variables]. PhD Thesis, University of A Coruña, A Coruña, 2014.
 61. Balague N, Torrents C, Hristovski R, et al. Overview of complex systems in sport. *J Syst Sci Complex* 2013; 26(1): 4–13.
 62. Barreira D, Garganta J, Castellano J, et al. How elite-level soccer dynamics has evolved over the last three decades? Input from generalizability theory. *Cuad Psicol Dep* 2015; 15(1): 51–62.