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ORIGINAL ARTICLE

Dynamics of the game in soccer: Detection of T-patterns

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Abstract
Traditional approaches to the quantification of team sports have proved to be limited in their ability to identify complex structural regularities that, despite being unobservable, nonetheless underlie the development of the sporting contest between opposing teams. This paper describes a method for detecting the dynamics of play in professional soccer through the analysis of temporal patterns (T-patterns). The observation instrument used was SOF-5, which is especially designed for studying the dynamics of the game in soccer. The recording consisted of within-session monitoring using the MATCH VISION STUDIO 3.0 software, while the THEME software was used to detect and analyse T-patterns. These T-patterns revealed regularities in the playing style of the observed team, FC Barcelona. The structures detected included a ball possession pattern, whereby the ball was first kept in the central zone before being played forward, through several moves, into the zones closest to the opposing team's goal in order to disrupt the latter's equilibrium. The results obtained show that it is possible to identify stable temporal structures that provide information about concurrent interaction contexts with respect to lateral position and zone. As such, the proposed methodology appears to be useful in detecting complex structures within the game of soccer, structures which may help coaches to design attacking and defensive strategies.

Keywords: *Dynamics of the game, T-patterns, team sport observation, soccer, interaction contexts, direct observation*

Introduction

In the field of sports research there is a growing need for the rigorous collection of data that provide empirical evidence about the complex reality they refer to. Key aspects in this regard include the presence of regularities that are not detectable through visual inference or traditional methods of data analysis, as well as the lack of standard observation instruments and the priority need to develop powerful, computerised coding systems, all of which must form part of an approach that is suitable for natural exercise environments (Kerr et al., 2006) and habitual contexts in soccer (Alcock, 2010).

The interaction between teams during a match is clearly a complex phenomenon and there are underlying assumptions which would constitute an interesting starting point for the study of various processes, for example, the analysis of dynamic systems or the social relationships between competing teams (Davids, Araújo, & Shuttleworth, 2005). However, there is no unified theoretical basis for the study of these processes, among which particular mention should be made of the inevitable multiplicity of individuals involved, the diversity of interactive structures, the effects of context, and the between- and within-session variability (Williams & North, 2009).

The data recorded by traditional studies of the dynamics of the game in soccer have been based solely on counting the number of certain behavioural occurrences, for example, the number of passes in a given area or the number of fouls committed by a team during the match, although some authors have studied effectiveness in terms of a multilevel approach (Beauchamp, Bray, Fielding, & Eys, 2005). However, most would agree that the game of soccer develops through the continuous generation of interaction contexts that vary throughout the match.

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The analysis of soccer therefore requires a diachronic system capable of including all the relevant information about any aspect related to these interaction contexts: for example, the lateral position or strip of the pitch in which the ball is located (longitudinal segmentation of the pitch), the zone (transverse segmentation of the pitch), the way in which ball possession is achieved and the way in which possession is lost (Lago & Martín, 2007).

One approach that has recently been used in different areas of sports research involves the detection and analysis of temporal patterns known as T-patterns (Fernández, Camerino, Anguera, & Jonsson, 2009; Jonsson et al., 2006). The basic premise here is that the interactive flow or chain of behaviour is governed by structures of variable stability that can be visualised by detecting these underlying T-patterns. In this context, the objective of the present study was to reveal the hidden yet stable structures which underlie the interactive situations (Shepherd, Lee, & Kerr, 2006) that determine the dynamics of play in soccer. More specifically, given that soccer involves a constant interaction between two teams, we sought to study the nature of these interactive events within the playing area, it being assumed that these temporal structures are not directly and immediately observable, and also that a large number of events occur simultaneously.

It should be noted, however, that the analysis of temporal structures is not being proposed as a substitute for conventional approaches in sports research. Rather, and as a complement to traditional procedures conducted on the basis of field notes (Andersson, Ekblom, & Krustrup, 2008; Gilbourne & Richardson, 2006), it seeks to offer a new perspective for observing the structure of one team's play with respect to that of the opponent.

Methods

The methodological approach taken draws upon recent developments in the field of sports research. Firstly, it is based on observational methodology, which is appropriate here given that soccer is played in a habitual context, is practised by professional players, and involves moves that are perceivable. From the technological point of view, the study makes use of digital recordings and computer analysis (Borrie, Jonsson, & Magnusson, 2002), which have been widely used in sports research (Luo, Wu, & Hwang, 2003), and specifically in soccer (Appleby & Dawson, 2002; Jonsson et al., 2006; Norton, Craig, & Olds, 1999; Xie, Xu, Chang, Divakaran, & Sun, 2004). These technological and methodological developments have greatly aided the preparation of recordings and episodic sampling, and also enable computerised coding with all the associated advantages in terms of recording quality, measurement of time, the capture of co-occurrences or diachrony.

Design

The observational design (Anguera, Blanco-Villaseñor, & Losada, 2001) was *nomothetic* (several matches), *point* (one match for each pair of opposing teams, and within-session recording throughout the match), and *multidimensional* (the dimensions correspond to the changing criteria of the observation instrument). The adoption of this N/P/M (nomothetic, point, multidimensional) design led to a series of decisions being made regarding the structure of the observation instrument, the type of data, data quality control, and data analysis.

Participants

The study is part of a broader research project involving the analysis of all games played by FC Barcelona (Spain) during the national League Championship and the Champions' League over several seasons. From these games we randomly selected five National League matches and five Champions' League matches from the 2000–2001 season (see Table I).

Instruments

Observation instrument. The on-going development of observation instruments has enabled us to conduct detailed studies of the dynamics of play in different

Table I. List of observed matches

Stadium	National League Matches	Champions' League Matches	Result
	FCB-Atlético Madrid		2–2
		FCB-Inter	3–0
Home		FCB-Liverpool	0–0
		FCB-Milan	0–2
	FCB-Zaragoza		4–4
		AEK-FCB	0–1
		Milan-FCB	3–3
Away	Racing-FCB		4–0
	Real Madrid-FCB		2–2
	Real Sociedad-FCB		0–6

team sports (soccer, basketball, handball and volleyball) (Fernández et al., 2009; Jonsson et al., 2006). The observation instrument chosen for this study was the SOF-5. This instrument is accompanied by a detailed coding manual, which includes the definitions of the codes that govern its use. It has been shown to have construct validity in terms of the rules of the sport studied and contrasting the opinions of experts and coaches.

The SOF-5 (see Table II) is also consistent with the proposed observational design, which is multidimensional in nature, and it is structured around

Table II. Criteria, categories and codes of the SOF-5 observation instrument (Castellano et al., 2000, 2008a)

FIXED CRITERIA	**TEAM**	**Observed team**			
		Opposing team			
	LEVEL	Club			
		Country			
	AREA	National			
		International			
	COMPETITION	League			
		Cup			
		Friendly			
	STADIUM	Home			
		Away			
		Neutral			
	HALF	First			
		Second			
		Extra time 1, 2			
	STANDING IN TABLE	League			
MIXED CRITERIA	**MOMENTARY SCORE**				
	ACCUMULATED SCORE				
	SYMMETRY / ASYMMETRY	Symmetry (11/11)			**S**
CHANGING CRITERIA	**LATERAL POSITION**	Right			**Ri**
		Centre			**Ce**
		Left			**Le**
	ZONE	Ultra-defensive			**UD**
		Defensive			**D**
		Central			**C**
		Offensive			**O**
		Ultra-offensive			**UO**
	POSSESSION				
			Ball in play		
		Begin		Recovery	**BR**
			Interruptions (ball stopped)	For / In	**BFI**
			Ball in play	For / Out / Foot	**BFOF**
		Final	Interruptions (ball stopped)	For / Out / Hand	**BFOH**
				Loss	**EL**
				Shot	**ES**
				For / In	**EFI**
				For / Out / Foot	**EFFOF**
				For / Out/ Hand	**EFOH**
				Against / In	**EAI**
				Against / Out /Foot	**EFAOF**
				Against / Out / Hand	**EAOH**
			Goal for		**EG**
	INTERACTION CONTEXTS		Rear line–Middle line		**R ⚽ M**
			Rear line–Attacking line		**R ⚽ A**
			Middle line–Rear line		**M ⚽ R**
			Middle line–Middle line		**M ⚽ M**
			Middle line–Attacking line		**M ⚽ A**
			Attacking line–Rear line		**A ⚽ R**
			Attacking line–Middle line		**A ⚽ M**
			Attacking line–Empty zone		**A ⚽ 0**
			Empty zone–Attacking line		**0 ⚽ A**

fixed criteria, *mixed criteria* and *changing criteria* (Castellano, Hernández, Gómez, & Fontetxa, 2000; Castellano, Perea, & Hernández, 2008a). The *fixed criteria* are only met at the start of the match, while the *mixed criteria* apply every time there is a change in the score or the number of players. By contrast, the *changing criteria* are recorded continuously throughout the observation of the match. Each one of these criteria gives rise to respective category systems that fulfil the E/ME conditions of exhaustiveness and mutual exclusivity (E/ME).

The dimensions considered in the present study correspond to the following criteria: lateral position, zone and interaction contexts

a. Lateral position (see Figure 1): Right, Centre and Left.
b. Zone: This refers to the zone of play (see Figure 1), defined according to five pitch areas or spatial strips: Ultra-defensive, Defensive, Central, Offensive and Ultra-offensive.
c. Interaction contexts: This refers to the momentary position of the ball in relation to the spatial configuration of the two teams and their lines, expressed by means of two letters which correspond to the lines that are performing the strategic action: "R" is the rear line, "M" is the middle line, "A" is the attacking line and "O" is the empty zone behind the rear line. The first letter corresponds to the line of the observed team that is nearest to the ball, while the second letter corresponds to the line of the opposing team that is nearest to the ball. The nine possible interaction contexts are therefore defined as follows:

- **R ⚽ M**: The ball is located between the **rear** line of the observed team and the middle line of the opposing team
- **R ⚽ A**: The ball is located between the **rear** line of the observed team and the attacking line of the opposing team.
- **M ⚽ R**: The ball is located between the **middle** line of the observed team and the rear line of the opposing team.
- **M ⚽ M**: The ball is located between the **middle** line of the observed team and the middle line of the opposing team.
- **M ⚽ A**: The ball is located between the **middle** line of the observed team and the attacking line of the opposing team.
- **A ⚽ R**: The ball is located between the **attacking** line of the observed team and the rear line of the opposing team.
- **A ⚽ M**: The ball is located between the **attacking** line of the observed team and the middle line of the opposing team.
- **A ⚽ O**: The ball is located between the **attacking** line of the observed team and the empty zone of the opposing team.
- **O ⚽ A**: The ball is located between the **empty** zone of the observed team and the attacking line of the opposing team.

Recording instrument. The recording instrument used was the MATCH VISION STUDIO 3.0 software (Castellano, Perea, Alday, & Hernández, 2008b). This is a highly flexible program into which the user first introduces all the codes corresponding to each one of the changing criteria of the SOF-5 observation instrument. All the co-occurrences of codes are then recorded, each of which occurs in a frame (the time unit used), and this produces a recording

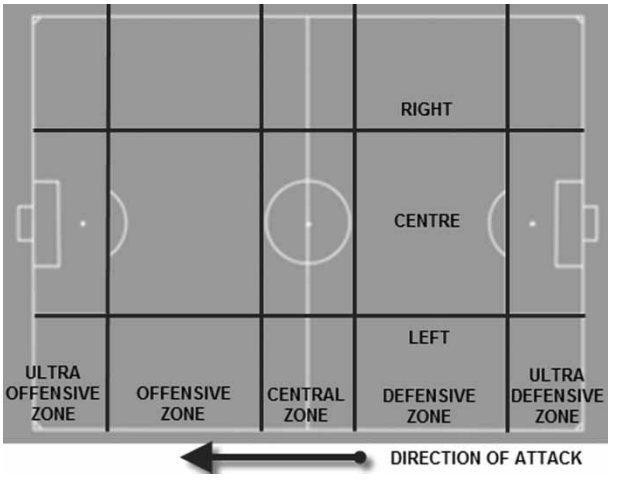

Figure 1. Lateral position and zone of play in the direction of the observed attacking team.

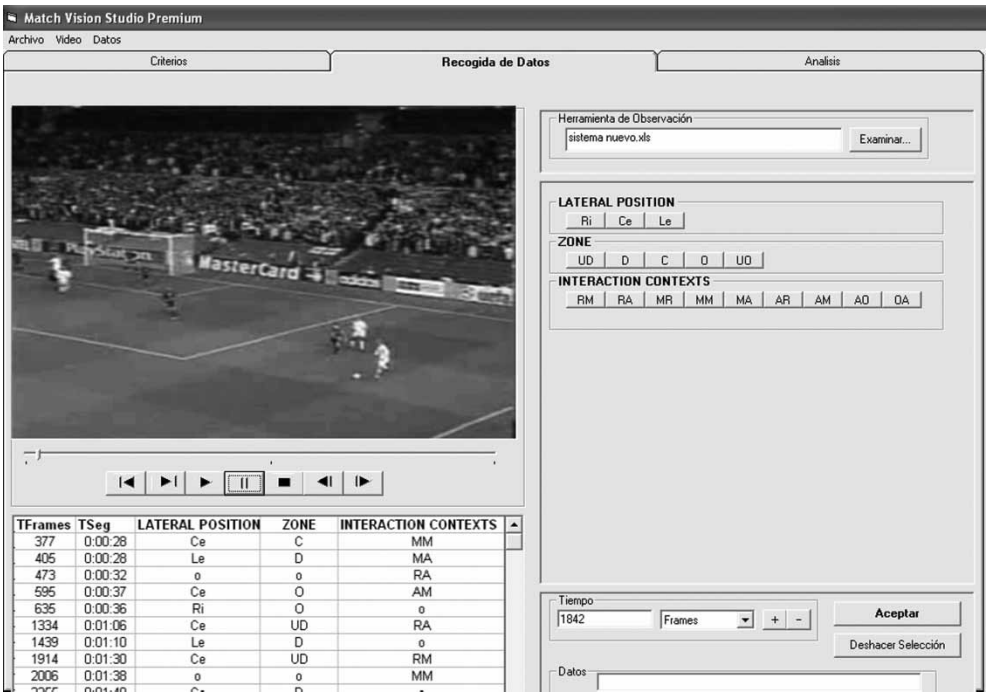

Figure 2. Screen capture from the MATCH VISION STUDIO 3.0 software (Castellano et al., 2008b) during recording.

formed by the successive co-occurrences; as such, the duration in frames of each one is recorded. The MATCH VISION STUDIO 3.0 software (Castellano et al., 2008b) enables the digital recording of matches to be viewed on a screen (see Figure 2).

Three different observers used the MATCH VISION STUDIO 3.0 software to transcribe all the recordings of observation sessions and obtain the corresponding event frequencies. This involved calculating the number of each kind of registered event, as well as the number of occurrences of each category independently of the other categories. Data quality (Blanco-Villaseñor & Anguera, 2000; Jansen, Wiertz, Meyer, & Noldus, 2003) was controlled by calculating the Kappa coefficient (Cohen, 1960). The values ranged between 0.75 and 0.85, which provides a satisfactory guarantee of data quality. The value obtained of 0.97 (for all criteria and all sessions) provides a satisfactory guarantee of data quality.

Procedure for detecting temporal patterns (T-patterns)

The recording of each game by MATCH VISION STUDIO 3.0 yields a series of Excel files comprising the successive configurations (groups of categories and lines); for example, (Ce, C, MM) or (Le, D,

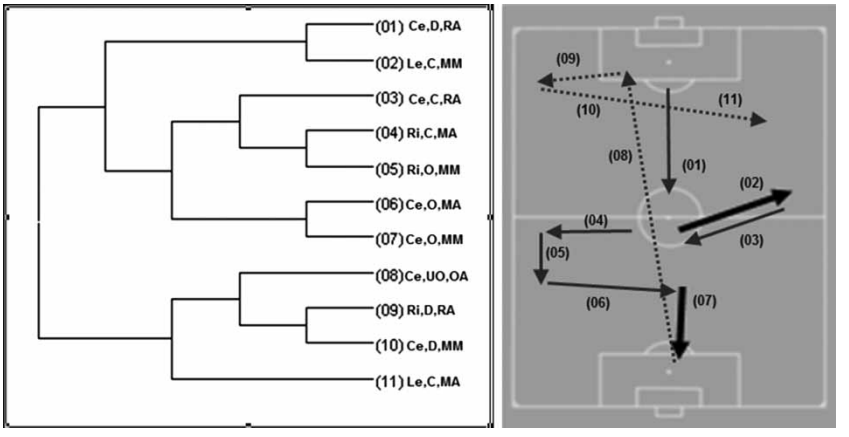

Figure 3. The left-hand side shows a representation of the first T-pattern found to occur in all the matches. The right-hand side illustrates the interpretation of the ball's path, showing how ball possession is concentrated in the central zone and the offensive zone, and predominantly in the central strip.

Table III. Fragment of a recording (2′ 30″) obtained using Match Vision Studio

	A	B	C	D	E
1	TIME (frames)	TIME	LATERAL POSITION	ZONE	INTERACTION CONTEXTS
2	377	0:00:15	Ce	C	MM
3	405	0:00:28	Le	D	MA
4	473	0:00:32	0	0	RA
5	595	0:00:37	Ce	O	AM
6	635	0:00:36	Ri	O	0
7	1334	0:01:06	Ce	UD	RA
8	1439	0:01:10	Le	D	0
9	1914	0:01:30	Ce	UD	RM
10	2006	0:01:38	0	0	MM
11	2255	0:01:49	Ce	D	0
12	2306	0:01:51	Ce	UD	RA
13	2368	0:01:53	Le	C	RM
14	2449	0:01:56	0	UD	RA
15	2482	0:01:57	Le	C	AM
16	2586	0:02:01	Ce	C	AR
17	2694	0:02:15	Le	O	MA
18	2919	0:02:28	Le	O	MM
19	2958	0:02:30	0	0	RM

MA) for the lines of codes that have changed, along with their temporality and duration expressed in frames and seconds (see Table III).

The next step involved importing these data into the THEME software (http://www.noldus.com/content/theme-0). This software allows the analyst to detect complex and repeated temporal patterns even when a multitude of unrelated events occur in-between components of the patterns, which typically makes them invisible to both the naked eye and to our knowledge. The basic assumption of the methodological approach underlying THEME is that the temporal structure of a complex behavioural system is largely unknown, but may involve a set of repeated temporal patterns, known as T-patterns (Magnusson, 1996, 2000, 2005). It should be noted that from this stage on, the data from all 10 matches were analysed simultaneously (Borrie et al., 2002).

Results

The total number of configurations (groups of categories and lines) recorded using the MATCH VISION STUDIO 3.0 software, for all 10 matches and based on the *changing criteria* of the SOF-5 (lateral position, zone and interaction contexts) was 7692 (see Table IV). The analysis of the recordings reveals a high number of T-patterns and shows that the occurrence requirement of a minimum of three co-occurrences was met, with $P < 0.005$. A number of different T-patterns, some occurring in cyclical fashion and on different levels of complexity, were detected in all the game segments analysed. Some patterns were found to occur not only among game halves but also across games. Table IV also shows the number of T-patterns obtained for each match and overall.

Each T-pattern can be represented graphically in the form of dendograms/tree graphs. These

Table IV. Number of T-patterns detected for all matches

	Number of recorded items/game events during each match		
Match	First half	Second half	No. of T-patterns
AEK–FCB	452	455	66
FCB–Atlético Madrid	386	333	57
FCB–Inter	335	372	46
FCB–Liverpool	519	386	39
FCB–Milan	370	351	22
FCB–Zaragoza	435	397	69
Milan–FCB	287	351	23
Racing–FCB	324	377	66
Real Madrid–FCB	387	359	51
Real Sociedad–FCB	365	451	68
ALL MATCHES			68

dendograms are then interpreted by identifying the codes which appear in the different category configurations they contain, following a chronological and descending order. Figure 3 shows the most representative dendogram corresponding to the attacking play of FC Barcelona (FCB) and found in all the matches analysed.

This first T-pattern represented by means of a dendogram/tree graph (see Figure 3) reveals an attacking structure that begins in the central defensive zone, before shifting to the right and left midfield wing areas, and then entering the offensive zone, as follows:

- (01): The attack begins in the central strip of the defensive zone through the attacking play of the FCB defenders (Ce,D,RA), who take on the attackers of the opposing team.
- (02), (03) and (04): Play then develops in the midfield area, with the ball being moved around i) the left-hand strip, where the middle-line players of FCB take on the middle line of the opposing team (Le,C,MM); ii) the central strip, where the FCB defenders take on the opposing team's attackers (Ce,C,RA); and iii) the right-hand strip, where the middle-line players of FCB take on the opposing team's attackers (Ri,C,MA).
- (05): Play progresses through the right-hand strip as far as the offensive zone, where it involves the middle lines of both teams (Ri,O,MM).
- (06) and (07): The attack materialises in the central strip of the offensive zone and involves the middle-line players of FCB and the opposition of, firstly, the forwards (Ce,O,MA) and, secondly, the midfield players (Ce,O,MM) of the opposing team.
- (08), (09), (10) and (11): The attack breaks through and ends in the central strip of the ultra-offensive zone, where it involves the forwards of FCB and the opposing team's goalkeeper (Ce,UO,OA), who manages to interrupt the attack. Play then moves to the central defensive zone via the opposing team's defenders (Ri,D,RA) or to the right-hand strip via its middle-line players (Ce,D,MM), who quickly initiate a counter-attack through the left-hand strip (Le,C,MA).

The second T-pattern represented by means of a dendogram/tree graph (see Figure 4) reveals another typical attacking structure that begins in the central defensive zone and then progresses through the left-hand strip, moving the ball back to the line immediately behind and then beginning the attack again from the same side, thereby creating other spaces through which to progress, as follows:

- (01) and (02): The attack begins in the central strip of the defensive zone (Ce,D,MM) and moves towards the central zone (Ce,C,MM) via the middle-line players of FCB, who are opposed by the lines of the other team.
- (03) and (04): Play then progresses through the left-hand strip as far as the offensive zone (Le,O,MM), before resuming in the central zone (Ce,O,MM) via the middle lines of both teams.
- (05): The attacking move has to change direction (backwards) and resumes again in the left-hand strip of the central zone (Le,C,MM), again via the middle lines of both teams.
- (06): The attack ends in the left-hand strip of the ultra-offensive zone, where the forwards of FCB are opposed by the other team's defenders (Le,UO,AR).

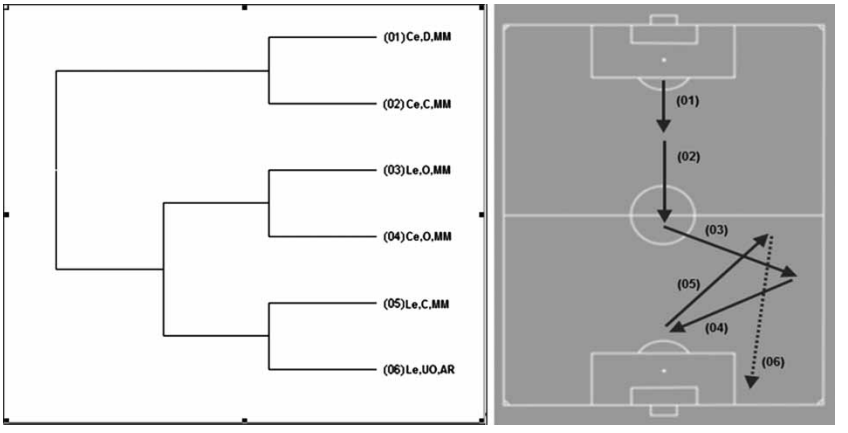

Figure 4. The left-hand side shows a representation of the second T-pattern found to occur in all the matches. The right-hand side illustrates how the attack begins in the central strip and takes shape through back-and-forward positional play in the left-hand strip.

Discussion

This study illustrates the enormous potential of an approach based on a specific observational design and the identification of T-patterns. As the latter cannot be determined directly or through visual inference, it was necessary to use the THEME software in order to identify the regularities embedded within a highly complex situation, in this case, soccer matches. The analysis revealed that the structure of play for FC Barcelona (FCB) is based on the creation of situations in which the ball is moved into zones that enable FCB players to disrupt the equilibrium of the opposing team. These zones are closer to the opposing team's goal, thereby facilitating goal-scoring opportunities. Furthermore, it can be seen that this movement occurs in stepwise form, with the ball being moved forward line by line.

Overall, the results obtained illustrate both the relevance of the analysis carried out and, in line with previous studies (Anguera, 2005; Jonsson et al., 2006), its potential for deepening our understanding of soccer. This is very important given that one of the principal goals of sport research is to enhance or search for ways of improving performance.

The recording instrument (SOF-5) has also been shown to be a powerful observational tool for studying the relationships between interaction contexts and the criteria of temporality and zone. Likewise, the MATCH VISION STUDIO 3.0 software has demonstrated its suitability for this kind of research, enabling us to obtain the matrix of all the co-occurrences of behaviour produced during the observed matches.

More specifically, the study of interaction contexts and the subsequent detection of T-patterns have enabled us to identify and define the playing style of the observed team. In this regard, one should note that a large number of temporal patterns can be detected in soccer. Indeed, the number, frequency and complexity of the detected T-patterns indicate that in team sports such as soccer, behaviour is much more synchronised than appears to the human eye, and certain behavioural regularities have been shown to exist. This synchrony appears on different levels, with variable temporal structures, and extends over time in a cyclic and acyclic way.

Conclusions

The study has shown that it is possible to identify stable temporal structures that provide information about concurrent interaction contexts with respect to lateral position and zone. The interpretation of the T-patterns obtained from all the matches analysed indicates that the style of play which the observed team FCB seeks to impose has the following characteristics:

a. The main objective of FCB, as it would be for most clubs, is to gain possession of the ball and thus prevent the opposing team from having possession.
b. Ball possession is preferentially sought in the central zone (C) and the offensive zone (O). This makes sense, since it takes the ball away from those zones in which loss of possession could prove dangerous for the team's own goal area. At the same time, FCB players move the ball into zones where an attempt is made to disrupt the equilibrium of the opposing team. These zones are closer to the opposing team's goal, thereby facilitating goal-scoring opportunities (see Figure 3).
c. The way of moving toward the opposing team's goal suggests that the playing style used is positional attack, since this movement occurs in stepwise form, moving the ball forward line by line.
d. The fact that the most representative interaction context is middle line–middle line (MM) suggests that the characteristics of attack are in accordance with what is indicated in the previous point, since this zone is the nexus between the rear line (R) and the attacking line (A).
e. Whenever there are many players in the zone through which the ball is moving, the observed team shifts the ball to the most adjacent rear line so as not to lose possession and to begin moving the ball toward the opposing team's goal through zones where there are fewer players.
f. Another notable aspect is the reiterated use of the central strip, this being relevant insofar as the observed team shows a preference for reaching goal-scoring zones by means of inside passes (see Figure 3).
g. The ball does not move around at a constant speed. Its speed of movement varies mainly at the beginning and, particularly, at the end of a move, probably so as to make it more difficult for the opposing team to intercept or recover the ball. These variations in speed are not constant, since they largely depend on how close the observed team is to the opponent's goal and on the number of players in the zone through which the ball is moving (see Figure 4).
h. It should be noted that in addition to the central strip the most widely-used lateral strip is the one on the left-hand side, as shown by the T-pattern represented in Figure 4 and the corresponding interpretative diagram. The observed team has several skilled players who take up

positions in the left-hand strip in order to make use of this area during play.

The study of interaction contexts and the subsequent detection of T-patterns have enabled us to identify and define the offensive playing style of FCB thus revealing its personality.

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