



An Accurate and Rapid System to Identify Play Patterns in Tennis Using Video Recording Material: Break Point Situations as a Case Study

by

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The goal of this study was to present an accurate and rapid detection system to identify patterns in tennis, based on t-pattern analysis. As a case study, the break point situations in the final matches of the clay court tournaments played during the seasons 2011 and 2012 between the tennis players Novak Djokovic and Rafael Nadal were chosen. The results show that Nadal achieves a higher conversion rate with respect to Djokovic in the break point situations, independent of the outcome of the match. Some repetitive patterns of both players were revealed in break point circumstances. In long rally sequences (higher than seven hits), the Spanish player won more break points, both serving and receiving, as a result of unforced errors of his opponent's backhand. In medium rally sequences (between four and seven hits), other factors such as the type, direction or serve location have shown to play an important role in the outcome of the point. The study also reveals that Djokovic frequently commits double faults in these critical situations of the match. This is the first time that t-patterns have been used to analyze the sport of tennis. The technique is based on computer vision algorithms and video recording material to detect particular relationships between events and helps to discover the hidden mechanistic sequences of tennis players.

Key words: tennis, break point, observation, t-patterns, Novak Djokovic and Rafael Nadal.

Introduction

Tennis is a sport discipline which depends on different fields of study, such as physiology (Fernández et al., 2006), sport injuries (Van der Hoeven and Kibler, 2006), psychology (Koning, 2011) and sport strategy (Katić et al., 2011). This research focuses on the field of sport strategy, analyzing some common sequences and mechanisms that players – consciously or not – execute to deal with key situations. Different authors have investigated elite tennis strategies using timing factors, shot details (Hughes and Clarke, 1995), and point profiles (O'Donoghue and Liddle, 1998). The specific analysis of the key situations is a factor of high interest (Djurovic et al., 2009; Losada et al., 2015), because the particular response behavior of the players in

these critical circumstances clearly affects the outcome of a match. Traditionally, most studies investigate situations on a quantitative basis, highlighting the frequency of conversion and/or the total number per player during a set, a match or a tournament (Knight and O'Donoghue, 2012; O'Donoghue, 2001). On the other hand, the qualitative analysis of these behaviors does not provide a total understanding of the play procedure or strategy performed by both opponents in the course of these tense situations. This lack of criteria makes it difficult to determine the pattern of play, which can lead to success or failure in the critical moments of a match. However, if such crucial information could be obtained by means of an objective criterion, it

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would be possible to establish an optimal strategy useful for players and coaches to adequately manage certain situations in a match.

When combining quantitative and qualitative methods, the approach becomes more consistent. As a consequence, in recent years, the number of studies integrating both methods has increased in the field of sport science (Camerino et al., 2014; Gutierrez-Santiago et al., 2011; Fernandez et al., 2009; Prieto et al., 2013). This combined method, also known as a “mixed method” (Anguera et al., 2014; Camerino et al., 2012a), is frequently applied to study some issues involving the complexity of the human motor behavior in other areas.

The purpose of this research was to solve the problem of the lack of criteria when identifying a play pattern in tennis, thus developing an accurate and rapid system. As a case study, we aimed to illustrate the potential of this method to analyze the break point (BP) situation. To avoid any type of bias, data were obtained from two of the current best players (Serbian player Novak Djokovic and Spanish player Rafael Nadal, 1st and 2nd, respectively, in the world ranking at the end of the clay court season in 2012, as defined annually by the Association of Tennis Professionals). Values were obtained during the BP circumstances, which occurred during the final matches between them in the clay tournaments of the seasons 2011 and 2012. Additionally, by applying both quantitative (the number of BPs and the percentage of conversion) and qualitative (pattern of play) analysis, the regular mechanisms used by both players in the decisive moments of the match were easily uncovered.

Methods

This study was carried out by employing an observational methodology which had been previously applied by other authors (Anguera and Jonsson, 2003; Black et al., 2005). Such methodology provides the rigor and flexibility required to study the behavior emerging naturally from a set of recordings of professional tennis matches. The results of the observational study were subjected to a mixed analysis including the sequential analysis of T-Patterns (Magnusson, 2000) and the descriptive statistics.

Design and Procedures

The type of observation carried out was systematic, open and non-participating. The

observational research method (Anguera et al., 2011) was ideographic (two players in a BP situation), traceable (the BPs during the clay court final matches in the 2011 and 2012 seasons between Novak Djokovic and Rafael Nadal), and multidimensional (different dimensions by the observation instrument). From this ideographic/traceable/multidimensional (I/T/M) study, we extracted a series of decisions concerning the participants, the observation and recording instruments, and the analysis procedure.

Observational instrument

The observational instrument developed for this study was OBSTENNIS (Table 1). This is a system of categories integrating the object under assessment, which in the case of this research was the pattern of play in the BP situation. OBSTENNIS is multidimensional in nature, which properly fits the method of observation presented in this study. Each dimension gives rise to a system of categories that accomplish the conditions of exhaustiveness and mutual exclusivity (E/ME).

The validation process of OBSTENNIS observation instrument was performed in three phases: 1) bibliographical review; 2) joint registration tests between the observers to detect faults and categories production; and 3) external experts analysis of the final observation instrument used.

Recording Instrument

Software LINCE (Gabin et al., 2012), a multimedia interactive program allowing simultaneous viewing and registering of the filmed material in a computer was used to support the observational analysis in a systematic way.

Case study data

A total of 82 BP events were analyzed during the final clay court tournaments between Nadal and Djokovic (41 situations per player) during the 2011 and 2012 seasons. Data were collected by capturing in video the retransmission of the final matches of Monte Carlo (2012), Rome (2011 and 2012), Madrid Masters 1000 (2011) and the Gram Slam final of Roland Garros (2012). Video editing software Pinnacle Studio v. 14 was used to edit all BP situations. After the observation and registration of all the actions, an excel file (.csv format) was exported from Lince software. The

file contained the sequence of the different BP situations between Nadal and Djokovic throughout all the tournaments. Additionally, the observation instrument applied from Lince software (.vvt format) was exported for validation purposes. Afterwards, all the relevant recording material was analyzed.

Quality control of recording data

Two observers carried out the quality control. The Cohen's Kappa (Cohen, 1968) test, obtained by means of GSEQ software (Bakeman and Quera, 2011, 1992), gave us a value of 0.97 (note that values greater than 0.80 are considered acceptable to ensure the agreement of the results). After this quality control test, an initial analysis of both players' BP conversion frequency was performed.

Data analysis

A descriptive analysis (Mean, Standard deviation) of the variables studied was performed. The results are shown in Tables 2 and 3. The Mann Whitney U test (non-parametric) was used to search for differences between both players analyzed. We performed a correlation analysis (Spearman test) to identify relationships between variables. The statistical assessment was performed using SPSS software to test the significance ($p < 0.05$) of the results obtained.

Detection of T-patterns

In order to detect the patterns of play, the observational instrument OBSTENNIS and the recorded BP situations were entered into THEME software. The temporal patterns (T-Patterns) were obtained using algorithms which were incorporated into the software package THEME v.5 (Magnusson, 2005, 2000). THEME and other similar software packages are able to detect statistically significant relationships between different patterns in sequences of behaviors based on different events, providing us hidden structures that cannot be uncovered by common statistical analysis. Authors have been exploring data with these types of software for almost two decades in a wide variety of disciplines (Camerino et al., 2012b; Gutierrez-Santiago et al., 2012; Louro et al., 2010), which has helped to reveal some sequences and hidden mechanisms. The basis of THEME is a test in a stepwise mode, that searches for significant sequences between two series of events and afterwards the sequences found are tested against other events and sequences,

searching for new connections. These steps are repeated until no further relationships are found. Thus, if two behaviors are connected in a higher frequency than that expected by chance, the program defines them as a T-pattern.

The detected patterns can be searched and filtered in different ways. This allows us to focus on important details. There are simple criteria like behaviors, pattern length, pattern frequency, and the number of actors involved in patterns. There are also some advanced criteria based on the relationships between patterns and the underlying event data. In general, the results provided by THEME are very consistent.

The T-pattern presentation is the same in all cases, the left quadrant representing the relationship established between the different criteria categories used (see observational instrument OBSTENNIS, Table 1). The reading must be carried out as a tree diagram from left to right. The right quadrant indicates how often the previous relationships take place using the lines that go from the top to the bottom. An overview of the position of the event types in the patterns gives an idea of their relative importance.

To analyze the sequences, the detection of temporal patterns was performed with the level of significance of 0.005 (implying that the percentage of accepting a critical interval due to chance is 0.5%). The minimum number of occurrences was fixed at ≥ 3 . In addition, to ensure the analytical precision, the reduction of redundancies and fast requirement, at all levels, was deactivated.

Results

The results are presented according to the guidelines of the mixed method. Firstly, we displayed the data obtained from a quantitative point of view, through a traditional descriptive analysis focused on the frequency and percentage conversion of BPs of both players and incorporating the variable of the winner of the match as well. Then, we performed a detailed descriptive statistics analysis of the results obtained. Finally, a qualitative approach was undertaken by means of a sequential analysis of the behavior of both players during BP situations. This provided some relevant information about the usual pattern of play.

Statistics Analysis

Table 2 shows the descriptive analysis of the

study variables.

The variables analyzed PS, S, SS and OP show considerable uniformity in both players. In the DR variable, few differences were observed, as evidenced that when Djokovic had a BP opportunity (Nadal serving) the DRs tended to be longer. In addition, the conversion rate of Nadal was higher than that of Djokovic by almost 10 points. The SEP greatly varied depending on who had the chance for a breakpoint. With regard to Nadal, the BP option tended to be ended with a forehand shot, while following Djokovic's play, the points tended to end with a backhand shot (regardless if it was a winner point or an unforced error).

The analysis by U test of Mann-Whitney revealed that there were significant differences in the variables depending on the length of the rally ($Z = 2.555$; $p = 0.011$) and the type of a shot at the end of the BP ($Z = 2.167$; $p = 0.030$), but not on the outcome of the point ($Z = 1.317$; $p = 0.188$).

The correlation analysis (Spearman test) revealed that when Djokovic had a BP chance there was a significant relationship ($r_s = -0.511$; $p = 0.001$) between the possibility of winning the point and the Spanish player service performance. Djokovic lost more points when Nadal successfully performed the first service and won when Nadal had to turn to the second service.

There was also a significant relationship ($r_s = -0.329$; $p = 0.036$) between the side where Djokovic directed his service and the winner of the point. Nadal won when Djokovic served towards the advantage side and lost when playing on the deuce side. This is probably because of Nadal left-handed condition, which allowed Nadal to play more comfortably at the advantage side when Djokovic performed a crossed or centered service.

If we only consider the points that ended with a forehand or backhand shot, there was a statistically significant relationship ($r_s = -0.351$; $p = .036$) between the length of the rally and the type of a shot that ended the point when Nadal had a BP option. When the points were longer, the rally finished with a backhand shot. When the rally was shorter, the tendency was to end with a shot to the right side.

A descriptive analysis of the BP conversion by both players studied ($n = 82$) is presented in Table 3.

In the 2011 season, Djokovic had more BP

chances than Nadal (23-9), but his conversion rate was lower (39.1 - 55.5%). In 2012, the opposite trends were shown. The Spanish player had more BP chances as compared to the Serbian player (32-18). In addition, Nadal converted more points in the BP situation than his opponent (19-9) and had a slightly higher conversion rate (59.4 - 50.0%). With the exception of the tournament of Rome 2011, when Nadal gained more BPs than Djokovic, but his conversion rate was lower, in the two seasons studied, the percentage of points saved by Nadal in the BP situation was clearly superior compared to those saved by the Serbian player (56.1 - 41.5%). Nevertheless, no statistical evidence was found ($Z = 1.317$; $p = 0.188$).

Detection of patterns of play

We obtained 130 t-patterns with the mathematical algorithm of the program THEME that discriminated sequences according to their complexity. The more complex structures we found were those related to five variables, although the predominant dendrograms displayed links with three or four criteria of the category system proposed. After a filtering process, based on the significance of the sequence detected (statistical criteria) and the relevance of the information revealed (intuitive criteria), a total of 12 T-patterns were selected and presented (Figures 1 and 2) for discussion.

Figure 1a shows a sequence in which Nadal tended to win the BPs, preceded by a RD greater than seven hits (OVSE), independent of the Djokovic service (first or second). Additionally, we also detected that winning Nadal BPs ended with a forehand shot (WI-FH). However, the most common situation was an unforced error of Djokovic (W-UE).

We found another relevant pattern related to the number of double faults (DF) committed by Djokovic in the BPs (Figure 1b). The Serbian player made five DF, two of them taking place in match point situations in two tournaments of the 2012 season.

Figure 1c shows the T-pattern analysis for medium DRs (four to seven hits, FOSE). We can on the one hand observe that Djokovic frequently won more points after a successful first service (FS), normally followed by an unforced error of Nadal (UE).

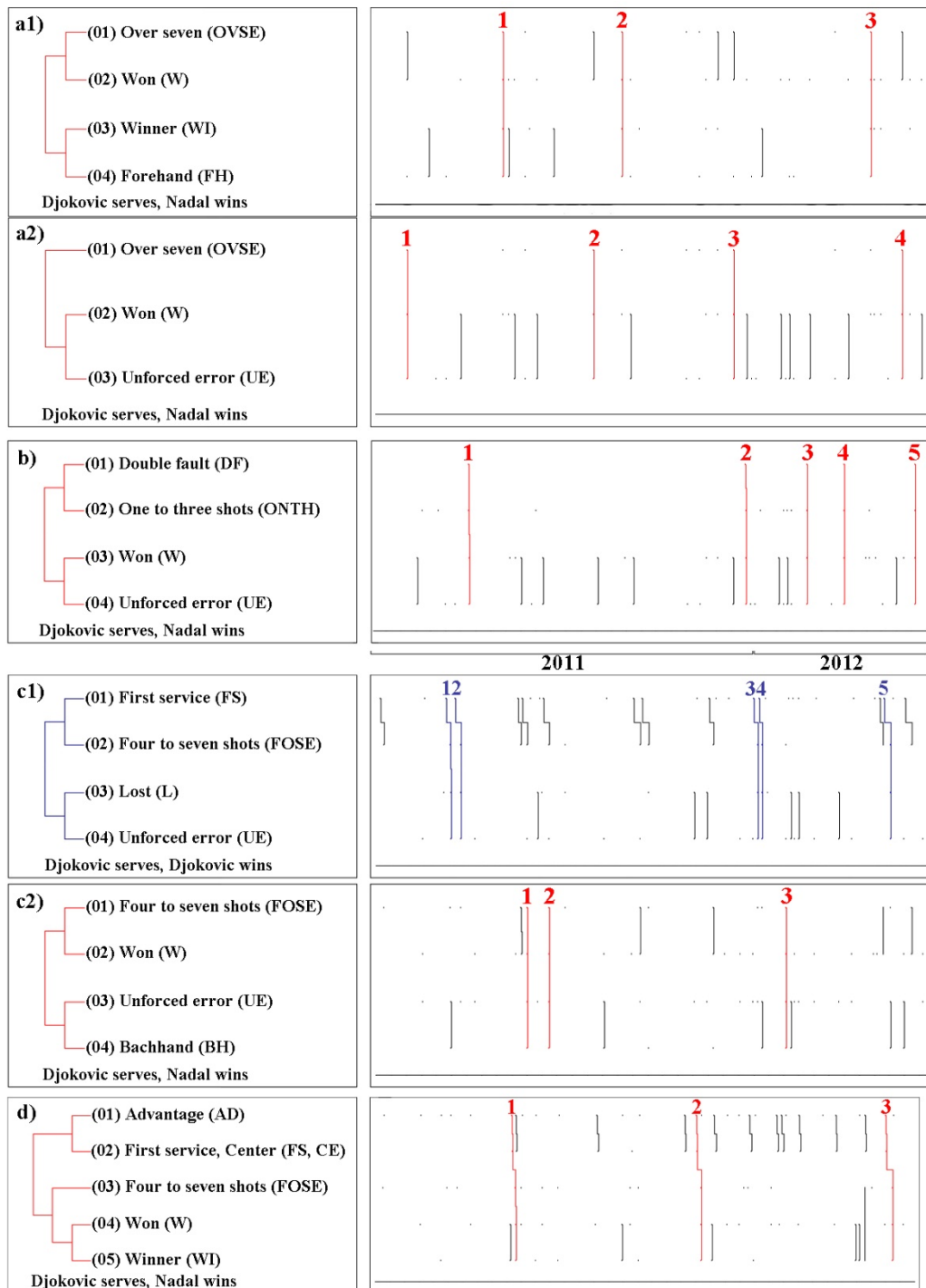


Figure 1

The break points T-Pattern when Nadal: a1-a2) is the receiver and the rally duration is higher than seven shots; b) is the receiver and Djokovic makes a double fault; c1-c2) is the receiver and the rally duration is between four and seven shots; and d) makes a service to the opponent backhand

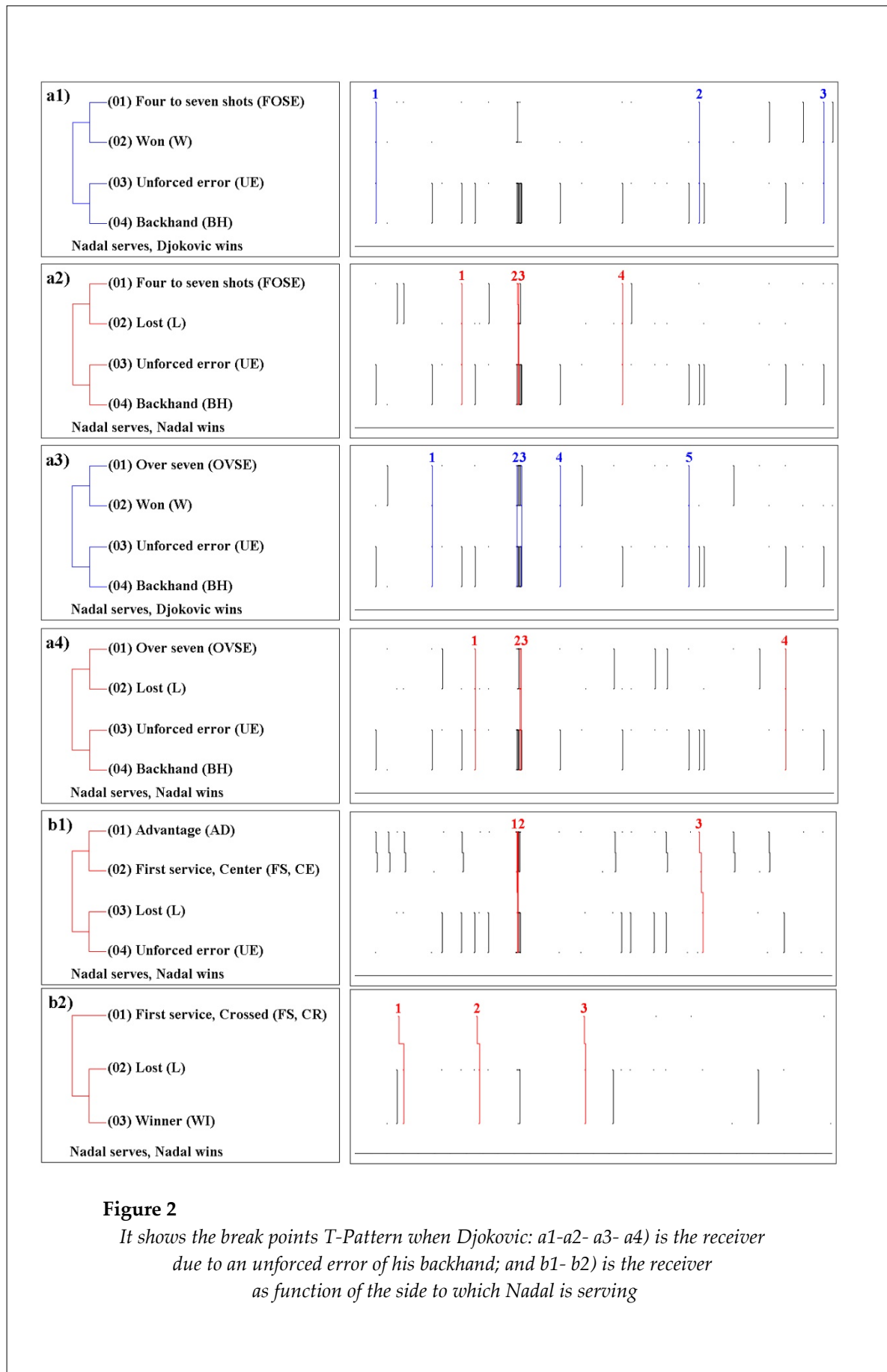


Figure 2

It shows the break points T-Pattern when Djokovic: a1-a2- a3- a4) is the receiver due to an unforced error of his backhand; and b1- b2) is the receiver as function of the side to which Nadal is serving

Table 1

Observational instrument OBSTENNIS

VARIABLE	CODE	DESCRIPTION
SERVICE PERFORMANCE:		
PLACE OF SERVICE (PS)	DE	The player serves to the deuce side-box.
	AD	The player serves to the advantage side-box.
SERVICE (S)	FS	The point is played with a first service.
	SS	The point is played with a second service.
	DF	The server player commits a double fault.
SIDE OF THE SERVICE (SS*)	T	The bounce after the service occurs towards the outside of the quadrant close to the T.
	CE	The bounce after the service occurs in the central vertical section of the service box.
	CR	The bounce after the service occurs towards the outside section of the quadrant.
BREAK POINT PERFORMANCE:		
RALLY DURATION (RD)	ONTH	The player makes an ace or the length of the rally is less than four hits.
	FOSE	The length of the rally is between four and seven hits.
	OVSE	The length of the rally is higher than seven hits.
THE OUTCOME OF THE POINT (OP)	W	The receiver wins the break point.
	L	The receiver loses the break point.
	WI	The outcome of the point is ended by a winning shot.
	UE	The outcome of the point is ended by an unforced error.
TYPE OF SHOT THAT ENDS THE POINT (SEP)	DSV	Ace
	FH	Forehand shot
	BH	Backhand shot
	PS	Passing shot
	SM	Smash
	DS	Drop shot
	LOB	Lob
	VL	Volley
	UTS	Unusual tennis shot
	NET	Net game

(*) The tennis court has two quadrants or service boxes in each side of the court with a width of 4.115 m. In this study, we divided each quadrant in three vertical sections. The central section has a width of 3.115 m (CE) and the outside sections of 0.5 m each (T and CR).

Table 2

Percentage obtained for the different study variables*.
The code notations are equal to those described in Table 1.

VARIABLE CODES		NADAL	DJOKOVIC
SERVICE PERFORMANCE:			
PS	DE	24.4	24.4
	AD	75.6	75.6
S	FS	70.7	70.7
	SS	17.1	29.3
	DF	12.2	-
SS	T	14.6	7.3
	CE	61.0	80.5
	CR	24.4	12.2
BREAK POINT PERFORMANCE:			
RD	ONTH	31.7	9.8
	FOSE	39.0	39.0
	OVSE	29.3	51.2
OP	W	53.7	43.9
	L	46.3	56.1
	WI	34.1	29.3
	UE	65.9	70.7
SEP	DSV	-	4.9
	FH	43.9	24.4
	BH	26.8	46.3
	PS	4.9	4.9
	SM	-	9.8
	DS	7.3	-
	LOB	-	2.4
	VL	2.4	4.9
	UTS	-	2.4
NET	2.4	-	

*The results are presented as function of the player that has the BP opportunity. The final shot describes how the BP ended.

Table 3*Distribution of break points in the clay court finals in the 2011 and 2012 seasons.*

	Rafael Nadal			Novak Djokovic			Winner
	BP	F. Conv.	% Conv.	BP	F. Conv.	% Conv.	
Rome 2011	3	2	66.7%	11	4	36.4%	Djokovic
Madrid 2011	6	3	50.0%	12	5	41.7%	Djokovic
Total 2011	9	5	55.5%	23	9	39.1%	
Monte Carlo 2012	8	5	62.5%	1	1	100%	Nadal
Rome 2012	7	4	57.1%	7	1	14.3%	Nadal
Roland Garros 2012	17	10	52.9%	10	7	70.0%	Nadal
Total 2012	32	19	59.4%	18	9	50.0%	
Total (2011 & 2012)	41	24	58.5%	41	18	43.9%	

F. Conv.: Frequency of conversion; BP: Break points; % Conv.: Percentage of conversion

On the other hand, the Spanish tennis player achieved a considerable number of medium duration rallies (FOSE) working over the opponent's backhand until he caused an unforced error (UE-BH).

In Figure 1d, we displayed another play pattern showing that when the Serbian tennis player performed a centered first service (FS, CE) into the advantage side box (AD) – Nadal's

receiving side – with a medium DR (FOSE), the Spanish player won the BP with a winning shot (WI).

When Djokovic played as a receiver and the rally lasted four to seven (FOSE) or more than seven hits (OVSE), the observed play pattern (Figure 2a) showed a balanced result (eight won by Djokovic and eight saved by Nadal), ending by an unforced error with their backhand (UE-BH).

Analyzing the efficiency of Nadal's serve as a function of the side (Figure 2b), we can observe that when he served to the center (close to the T) into the advantage box (AD - FS, CE), Djokovic lost the BP due to an unforced error (L-UE). In addition, when Nadal made a successful first cross service close to the external line of the service box (FS, CR), Nadal saved the BP with a winning shot (WI).

Discussion

Implications of the study

This research proposes a new sequence detection system in the discipline of tennis as a solution to identify play patterns. As mentioned above, the analysis of central moments of a match, such as BPs, service, match and set points, etc., has historically focused on describing the frequency of conversion (quantitative analysis) not having yet been studied from a strategic point of view (qualitative approach). This study allowed us to detect the play pattern used by both players to win or save BP situations as a case study. However, it can also be useful for other key circumstances, helping to reveal the strengths and weaknesses of each player, and allowing coaches and players to establish an optimal strategy for the game.

The difficulty of consolidating a BP has already been investigated by other researchers (Katić et al., 2011; Klaassen and Magnus, 2001; O'Donoghue, 2001) who concluded that the possibility of saving a BP was: (a) higher in male than in female tennis category; and (b) higher in fast court (grass or concrete) than in clay (slow bounce) surface tournaments. Data from 214 serving performances from Grand Slam singles tennis matches in 2007 (O'Donoghue, 2008) showed that the advantage of a serve still existed in points of 3 to 4 shots on the first, but not on the second serve. On the second serve, men lost the advantage of a serve once the rally reached a third shot. By contrast in women's singles, the advantage of a serve was lost after the first 2 shots of the rally when the first serve was in and there was no significant serve advantage when a second serve was required. The first serve in men's singles tennis at Grand Slam tournaments gave the server such an advantage that 62.4% of points of 3 to 4 shots were won, which is significantly greater than 49.7% of points won when the rally

lasted for 5 or more shots.

In addition, we studied the frequency of BP conversion on clay courts, finding that: (a) in absolute terms, the average percentage of conversion of the BPs when Djokovic was the receiver was 43.9%, similar to the values described by Knight and O'Donoghue (2012) for professional tennis players who played in Grand Slam competitions during 2008 and 2009 (42.0%); (b) in relative terms and taking into consideration the outcome of the match, the conversion rate achieved by Djokovic when he won was lower than the values indicated by Katic et al. (2011) for the winning players (39.1 - 45.5%). On the other hand, when he lost, his conversion rate was higher than that reported by the same authors for the losing players (50.0 - 36.5%). The study by Filipčič et al. (2008) clearly shows a higher average conversion frequency of BPs for the winners than for the losers (52.6 - 33.7%). However, these statistics do not adjust to the figures found for the Serbian player when Nadal was the opponent (Table 2).

O'Donoghue (2003) identified different types of a tennis player with respect to how a game score influenced strategy. Correspondingly, it was determined that the Spanish player had an average conversion frequency, both as a winner (59.4%) and as a loser (55.5%), higher than the frequency published by Filipčič et al. (2008) and Katic et al. (2011). O'Donoghue (2012) showed that only Rafael Nadal won a greater proportion of break points than non-break points and Novak Djokovic was unaffected by a score-line, winning a similar proportion of break to non-break points. In absolute terms, the marks obtained by Nadal are higher (58.5 - 42.0%) than those indicated by Knight and O'Donoghue (2012).

The sequential structure of the BP situations has not been explicitly analyzed by the scientific community although several works have addressed this issue with the application of probabilistic and predictive models (O'Malley, 2008) as a function of the number of shots per rally, the type of serve or the winning shot used (Crognier and Féry, 2005; Pollard, 2008). These studies clearly show sequential patterns of play during the BP situation as a function of the factors analyzed.

The trend is that Nadal wins the BPs with rallies lasting more than seven hits, both when

receiving and serving. In general, the data show the superiority of the Spanish tennis player even when the advantage of the service initiative is no longer maintained. In any case, as already mentioned by Howard (1987), regardless of who wins the point, the typical sequence is that Nadal obtains the BP because of an unforced backhand error of his opponent.

If the duration of the rally is short as previously indicated by Magnus and Klaassen (1999), O'Donoghue and Brown (2008) and Pollard (2008), the first service will clearly determine the winner of the BP. When the BP ended with a medium duration rally (four to seven shots), other factors such as the type of service or the side, can play an important role regarding the result. In general, we found the following play patterns related to the service: (1) when the Serbian tennis player succeeded with his first service, the common sequence was that the BP ended with an unforced error by Nadal; (2) when the Spanish player served to the backhand of his opponent (advantage box), he usually saved the BP by taking advantage of his left-hand status, hitting back with a winning shot towards Djokovic's backhand; (3) when Djokovic made a centered service (to the T), Nadal took again advantage of his left-hand condition, hitting back to Djokovic's backhand and winning the BP, an event that occurred on several occasions.

Previous analyses have confirmed that the left-hand condition of Nadal is a tactical advantage against Djokovic, a situation already generalized by other authors (Hagemann, 2009; Loffing et al., 2010).

Numerous studies (Ferrauti et al., 2001; Filaire et al., 2009) show that pressure can alter the player's concentration. During the 2012 season, Djokovic lost all clay court tournaments against Nadal. We observed that Djokovic mislaid numerous adverse situations such as the BP, committing several double faults in critical moments of the game.

Summary of the results obtained

After performing the analysis of the BP situations between Nadal and Djokovic during the 2011 and 2012 seasons, we can conclude that: (1) the OBSTENNIS observational instrument application combined with appropriate statistical software has proved to be a valuable tool to detect patterns of play in tennis; (2) the player achieving

a higher number of BP opportunities during the game tended to win; (3) the frequency of BPs converted and saved by Nadal was better than that obtained by Djokovic; (4) in general terms, Nadal's frequency of converted and saved BPs was higher than the average frequency found in other studies, independent of the outcome of the match. On the other hand, Djokovic's frequency was similar to the average observed in other players; (5) when the number of hits in a rally was higher than seven, Nadal frequently won the BP event against Djokovic, regardless of who was the server, and usually ending with an unforced backhand error; (6) the first service of the Serbian tennis player was crucial in the BP situations; (7) Nadal took advantage of his left-handed condition in the BP situations.

The results presented are complementary to those found recently by other authors (Losada et al., 2015), in which, following results of a log-linear regression method, they indicated that the player had lower effectiveness in shots made from the left side and greater effectiveness in the drive and backhand executions at the middle of the tennis court or at the bottom right side.

Conclusions

In this paper, we do not really aspire to find consistent statistical evidence of our affirmations. The goal was only to show, using a key example, the advantages of t-pattern analysis for the detection of hidden recurrent actions (or patterns) and the probabilistic interactive sequences of players in the sport of tennis. We studied the matches of two players in similar circumstances (clay court surfaces, analyzing only the final games, for the two best players at the peak of their career) in critical moments of the game (BP situations). The results obtained show a potential alternative for the sport of tennis to identify play patterns in a quick and accurate way.

This study focused on the presentation of a new system to identify play patterns in tennis, using the BP situations in final matches between Novak Djokovic and Rafael Nadal, on clay court tournaments in 2011 and 2012 seasons as a case study. The major pitfall of the approach suggested is the lack of data to perform the analysis. This is due to the difficulty to find similar conditions (type of court, players, equivalent tense situation

as the final of a tournament, among others) to ensure the absence of bias in the analysis. Sometimes, this problem will cause a non-statistical relationship, which could be exacerbated when we subdivide the data. In our opinion, players only intuitively understand the relevant facts, sometimes only at the time they are playing; these may not be determined in a statistically significant way due to the small number of cases, but they are often the key for deciding the outcome of a match. Our aim was to demonstrate in a statistical, consistent basis these facts (and not only the intuitions) by means of a computer program analysis. However, regarding the mechanistic behavior of tennis players, we consider the intuitive disclosure of the facts making a player lose a final as relevant as their statistical significance. Many researchers are becoming conscious of the potential of the t-

pattern analysis and they apply this tool in many different fields of study. In this work, the most important innovation was the application of the t-pattern tool to the sport of tennis.

Consequently, considering the amount of time that players, coaches, researchers, sport journalists and other professionals spend in analyzing the mechanistic behavior of tennis players, we think that this paper can be very useful. We are confident that, if accepted, the technique presented (or similar) could be used to search play patterns in many different circumstances, including: (a) in specific terms, larger numbers of players applying similar head-to-head analysis; and (b) in general terms, top players in different types of tennis courts for different seasons.

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