A Monte Carlo assessment of suspense in sports and games

Emmanuel Dion

A MONTE CARLO ASSESSMENT OF SUSPENSE IN SPORTS AND GAMES

Emmanuel Dion
Marketing Professor at Audencia, Nantes School of Management
Audencia Nantes School of Management
8 route de la Jonelière F-44300 NANTES
E-mail: edion@audencia.com

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ABSTRACT

This paper analyses how the scoring systems actually and potentially used in a variety of sports and games affect the suspense they can generate. The experimental method relies on several Monte Carlo simulations applied on a comparative basis to basketball, table tennis and tennis. Results show that simple systems such as basketball scoring tend to generate limited uncertainty whereas stratified systems such as tennis scoring favour a higher level of unpredictability, hence suspense.

INTRODUCTION

Little if any research has been undertaken until now about how scoring systems affect the progress types of sports matches, along with their propensity to generate suspense. This fact is all the more surprising that huge issues relating to sports fans' interest and media coverage are at stake, resulting in potentially major financial consequences.

This point would be of little practical value if the sports scoring systems were absolutely fixed as part of the games' universal history. This assumption is reinforced by the fact that some scoring systems have their roots deep in their sport's history. For instance, the 15 – 30 – 40 – game progress in tennis games is said –without proof- to come from the presence of clocks next to some tennis courts (*jeu de paume*) halls in France centuries ago. But historical fixity does not hold if we observe that:

- volleyball has fundamentally changed its scoring system in 2000. With the former system, points could be scored only when a team had the service -side-out scoring- and all sets went up to only 15 points versus 25 points now.
- rugby has two major variations, along which even the number of players involved in the game changes. In 2005 (vs. the original 1905 rules), a try is worth 5 points (vs. 3), a conversion 2 (unchanged), a penalty 3 (unchanged) , a drop goal 3 (vs. 4).
- basketball is played with different rules in Europe and in the United States of America
- tennis has changed several times its scoring system during its history, the last change dealing with doubles: shortening of the sets, disappearance of the advantage rule, emergence of a super tie-breaker that replaces the decider. Not to mention the differences between professional tournaments, some matches being played in three or five sets, with or without a tie-breaker in the decider.
- Etc.

All those considerations are related to major sports that have a dominant position among entertainment activities offered to man and a strong history that tends to make them change-resistant. By contrast it is therefore easy to imagine how flexible scoring systems can be in general, which might sound counter-intuitive at first, because scoring tends to be unconsciously admitted as the most fundamental set of rules of a game, since it defines exactly the goal that players should aim at.

In fans' perception it is hard to define which comes first: the conscience of the score, or the attention to style. In fact, both seem to be intricately intertwined, as is being exemplified by the following excerpt of an internet chat (see Figure 1). Thousands of chats' excerpts would show the same thing as these lines that were written during the final match of the Tennis Masters Cup held in Shanghai in November 2005: suspense, tension, attention (and hence economic potential) mainly comes from the score line progress.

"Federer_Express_2000
20.11.2005 | 12:44: Its not looking good, this shouldnt have goned to 4, damn it!

Sally-Suzanne
20.11.2005 | 12:45: 15-0 Roger! […]

mary91
20.11.2005 | 12:45: Oh,my God! I don't watdh Roger's match?but I will die............soon

Melanija
20.11.2005 | 12:46: Let's all stay positive. Let's all believe he will make it in the end.

Sally-Suzanne
20.11.2005 | 12:46: beautiful shot from Rog! 30-0!

Sally-Suzanne
20.11.2005 | 12:47: just long from Roger . deuce now!

Federer_Express_2004
20.11.2005 | 12:47: So far Nalbandian has not given up nothing to Roger, no breakpoints this set.

Sally-Suzanne:
20.11.2005 | 12:47: i know its 4th set, whats the game score?"

Figure 1 – Excerpt from **http://www.rogerfederer.com**
(typing mistakes have intentionally not been corrected)

We can easily see in this example how comments about the game and style are mixed in depth with comments about the score. In this perspective, the scoring does not appear any more as a pure relative social construct, but as an intangible state of the world. In other words, it becomes in fans' minds part of a first-degree apprehension of facts.

This should not mislead sports' organizers and managers : scoring systems are not intangible, even though they have to keep this imaginary property in fans' minds. Scoring systems are efficient tools that contribute to define the potential of attention or interest that might arise from sports shows. Undertaking scientific research on the topic might therefore be of considerable economic value.

METHODOLOGY

The experiment relies on a Monte Carlo based simulation that reproduces the progress of scoreboards based on various scoring systems: to be able to compare scoring systems on a coherent basis, we have chosen to concentrate on major sports that:

- (1) rely on a succession of *n* independent phases (rallies in tennis, table tennis, or volleyball, offensive action in basketball, touches in fencing) that lead to score a large number of times throughout a match
- (2) with *n* usually ranging between 50 and 200 (*n* is never fixed in advance to preserve suspense although a minimum value can be set).

Note that many sports could be adapted to make this scoring system suitable for them without changing their fundamentals: shooting, archery, bowling, golf, etc. However, condition (2) excludes all sports and games for which scoring is rare (such as ice hockey or soccer) or unique (such as races or most combat sports).

For the purpose of clarity, we have chosen to concentrate on three sports that illustrate two extreme and one medium scoring options:

- **basketball** illustrates a simple method in which points are simply added from the start to the end of a match (shots may bring 1, 2 or 3 points but this does not change the core linearity of the method), the goal being to score more points than the other team. There is only one level of scoring.
- **tennis** illustrates a complex method in which points have to be capitalised in games and games have to be capitalised in sets to decide who is the winner (3 levels of scoring). Optionally, when games go to deuce, another minor level of capitalisation exists with the advantage rule. In this experiment we have only investigated the most current type that consists of three-set matches (the first player to win two sets wins the match).
- **table tennis** illustrates a medium option with two levels of scoring: points and sets.

A computerised Monte Carlo simulation tool has been developed (using Excel ® and VBA ®) and used to reproduce the repeat of a very large number of matches relying on those three scoring systems and examine results from a statistical perspective.

Various sets of probabilities have been used to test the model.
Set A ("Equal") – Set A gave each player (or team) a constant and equal point win probability of 0.5. This allows to measure the degree of suspense generated in matches between two players (or teams) of equal strength. Set A has been run 10,000 times to ensure a good level of histogram smoothing.
Set B (p) ("Constant") – Set B gave player 1 a constant point win probability of p (and hence player 2 a constant point win probability of 1-p), p being different from 0.5. This allows to measure the degree of suspense generated in matches between two players (or teams) of unequal strength, the difference between the two being integrated in the model as a parameter. Set B has been run 1,000 times for the following values of p: 0.4, 0.425, 0.45, 0.475, 0.5. For values smaller than 0.4, matches were so unbalanced that conclusions would not have been significant anyway.
Set C (p, p', t) ("Turnaround") – Set C gives player 1 a point win probability that swaps from p to p' at time t during the match. This allows to measure the capacity of the scoreboard to reflect the change in the momentum of matches that tend to turn around at a given point due to the rise of a player and/or the fall of his competitor.

The device had to be slightly improved for basketball simulation, since:

- winning shots have a value of one to three points depending on the circumstances (free throws, shots from inside or outside the 3 –point line).
- the probability of one team scoring is dependent on their being on the offensive side, which in turn results from the last occurred event (opponents scored or missed).

For this reason, a special simulator has been built that reproduces the full sequence of events occurring in a match, second after second. The simulator consists of 2880 lines of events (corresponding to the 2880 seconds of a match) for which any of the following events can occur, with an appropriate probability distribution:

- Team 1 is in control of the ball and nothing happens
- Team 1 is in control of the ball and scores 1 point. Team 2 takes control of the ball.
- Team 1 is in control of the ball and scores 2 points. Team 2 takes control of the ball.
- Team 1 is in control of the ball and scores 3 points. Team 2 takes control of the ball.
- Team 1 loses the control of the ball (the ball is intercepted, a shot is missed and the opposite team wins the rebound, or there is a foul)
- All of the above for team 2

The set of probabilities used for each line depends upon the set of probabilities used for the previous lines, thus solving the non-independency-of-events problem. All probabilities have been computed from empirical data collected from

NBA statistics for the start of season 2005, widely available on the internet (see table 1. Source: Atlantic Division of Eastern Conference, start of season until 14. December, website used: http://www.allbasketball.com/nba/05-06/stat_cum/index.php). In case of simulations with sets B or C, the sets of probabilities used were changed to care for the impact of p and p'.

Table 1 – Empirical data used for probability sets definition

	Side change	Score 2 points	Score 1 point	Score 3 points	Lost rebound when offensive	Lost ball control	Matches played
Boston Celtics	950	613	399	104	606	344	20
New Jersey Nets	922	553	409	98	625	297	19
NY Knicks	955	580	409	59	588	367	19
Philadelphia 76ers	1000	699	489	91	712	288	21
Toronto Raptors	1000	626	409	120	708	292	21
Total	4827	3071	2115	472	3239	1588	100
Average occuring time in seconds	60	94	136	610	89	181	

For all three sports investigated, a number of indicators have been defined to measure suspense.

- **Length variability ("Length")**
- **Pivot point ("Pivot")**: position of the first time in the match when one player (or team) takes the lead and keeps it until the end of the match. This measure is expressed in terms of percentage of progress in the match (0% being the start, 100% the end).
- **Number of equalities ("Equalities")**: Number of times when the leader changes throughout the match, including ties.
- **Immediacy ("Immediacies")**: propensity of the match to come close to a possible end.

For all those indicators, no fixed optima can be determined other than by undertaking some kind of psychological experimentation. However, it is easy to understand that the best quality of suspense is generated for:

- Undetermined length, even though the match should always seem to progress.
- Usually late but fundamentally undetermined pivot point for set A. Appropriate dependency over p, p' and t for sets B and C.
- Average number of equalities in all cases, with a dependence on p-p' for set C
- Potentially long but fundamentally undetermined immediacies especially for set A and to a lesser extent for set C.

If the score progresses in a chaotic way, with the outcome of the match being unpredictable until the very last points, the attendance might feel perplexed and reluctant to focus their attention during the first and middle stages of the match. But on the contrary if the score progresses along a too predictable line, the attendance might get bored and lose their attention well before the end. A good scoring system is a scoring system that allows some limited turnarounds on the scoreboard until the end of the match, with a turnaround occurrence probability decreasing over time but always remaining dependent upon a possible shift in players' momentum. Only this combination can allow fans to write in their minds, while attending a match, an imaginary story that will keep their attention and memories open.

RESULTS

In this paper we will only discuss the results observed for sets A and B, and leave set C findings for further research and discussion.

A – Length variability

Note : In this section, length means number of scoring events (points in tennis and table tennis, winning shots in basketball), and not duration.

Tennis, table tennis and basketball have relatively different schemes in terms of length for set A. Statistical indicators and probability distributions are displayed on table 2 and figure 2. Although the length means are similar, the standard deviations vary considerably, basketball being much more predictable (and therefore compatible with television standards) than table tennis and tennis. The table tennis curve has three local maxima corresponding to matches that go to 3, 4 or 5 sets (the last two being slightly more frequent than the first). The same effect exists, but very much attenuated, for tennis matches that can go to 2 or 3 sets.

Table 2 – Length statistics for set A

	Tennis	Table tennis	Basketball
Mean	164,60	153,62	189,01
Std.	42,51	30,05	17,83

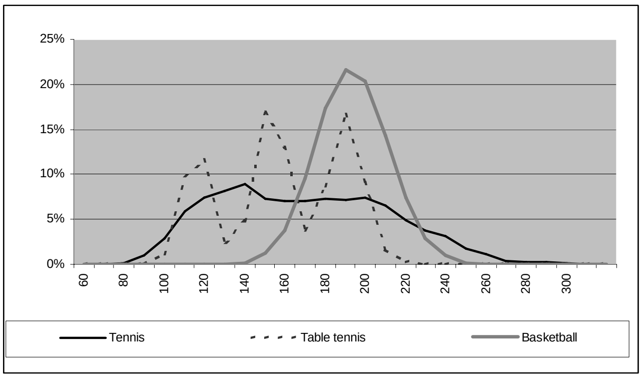

Figure 2 – Length distribution for set A

When point win probabilities change (see set B tables and figures, numerated from 3a to 3c for details), we can observe that length means and standard deviation decrease simultaneously for tennis and table tennis while being almost unchanged for basketball (technical note: values for set B and p=0.5 are different from those of set A because they have been computed again on a smaller basis to ensure compatibility with other values of p).

Table 3a – Length statistics for set B (Tennis)

	p = 0,5	p = 0,475	p = 0,45	p = 0,425	P = 0,4
Mean	163,22	158,67	142,04	121,67	109,11
Std	42,36	43,02	40,91	31,49	27,23

Table 3b – Length statistics for set B (Table tennis)

	p = 0,5	p = 0,475	p = 0,45	p = 0,425	p = 0,4
Mean	153,20	148,21	137,77	124,79	113,81
Std	30,77	30,87	30,11	27,28	21,44

Table 3c – Length statistics for set B (Basketball)

	p = 0,5	p = 0,475	p = 0,45	p = 0,425	p = 0,4
Mean	188,25	188,37	190,62	190,62	192,66
Std	17,84	16,75	18,23	17,16	17,49

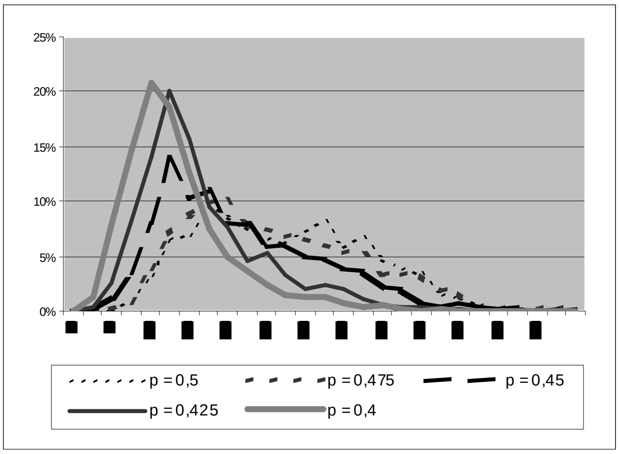

Figure 3a – Length distribution for set B (Tennis)

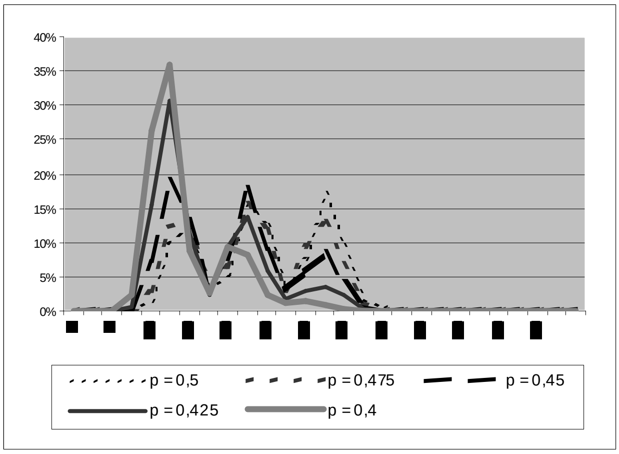

Figure 3b – Length distribution for set B (Table tennis)

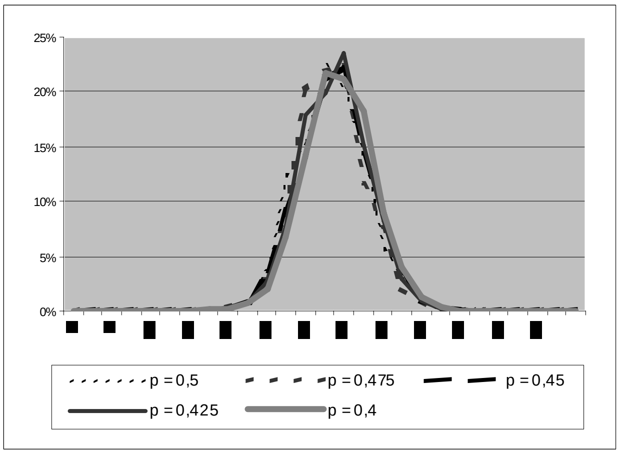

Figure 3c – Length distribution for set B (Basketball)

B – Pivot points distributions

In all three sports investigated, matches tend to pivot anytime when play is under way, with higher probabilities in the end though. Basketball tends to choose its winner right from the start slightly more often than others (see figure 4).

Globally, the basketball distribution curve in much smoother, and seems to show that the winner will appear most likely close to the beginning or the end of matches, while the other sports' curves look more chaotic. For table tennis, we can observe the three aforementioned peaks corresponding to the three possible number of sets. For tennis there is a slight alternance of relatively high or low probabilities of decision, the highest coming right at the end. Tennis is the sport for which in case of equal strength players, matches are decided most often during the last 10% of play.

Table 4 – Pivot points statistics for set A

	Tennis	Table tennis	Basketball
Mean	57%	56%	51%
Std	33%	34%	35%

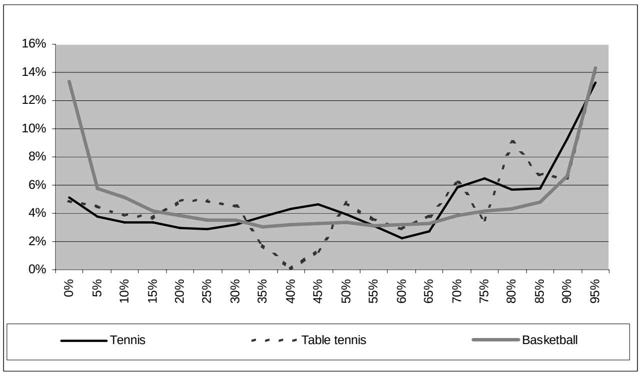

Figure 4 – Pivot points distribution for set A

The effects mentioned for set A remain observable for set B ans various values of p (see tables and figures 5a to 5c). Quite obviously, pivot points tend to appear all the more sooner in the matches that the point win probabilities is unequal between players.

Note that for some reasons, table tennis matches almost never turn around between 40% and 45% of play.

Table 5a – Pivot statistics for set B (Tennis)

	p = 0,5	p = 0,475	P = 0,45	p = 0,425	p = 0,4
Mean	0,56	0,52	0,42	0,29	0,22
Std	0,33	0,34	0,32	0,28	0,24

Table 5b – Pivot statistics for set B (Table tennis)

	P = 0,5	p = 0,475	P = 0,45	p = 0,425	p = 0,4
Mean	0,56	0,51	0,42	0,30	0,21
Std	0,34	0,35	0,33	0,30	0,24

Table 5c – Pivot statistics for set B (Basketball)

	p = 0,5	p = 0,475	P = 0,45	p = 0,425	p = 0,4
Mean	0,49	0,45	0,33	0,22	0,13
Std	0,35	0,35	0,31	0,25	0,17

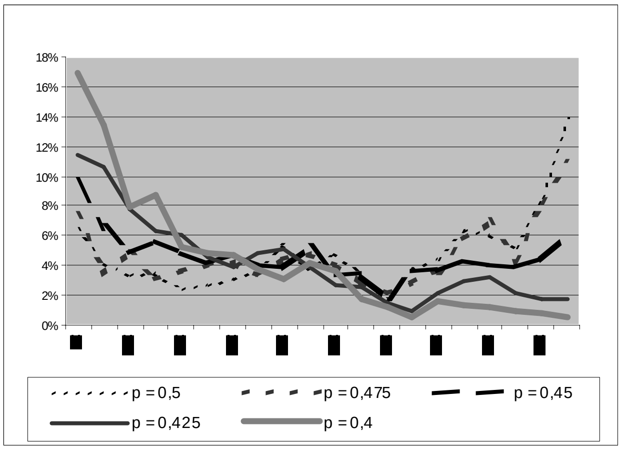

Figure 5a – Pivot distribution for set B (Tennis)

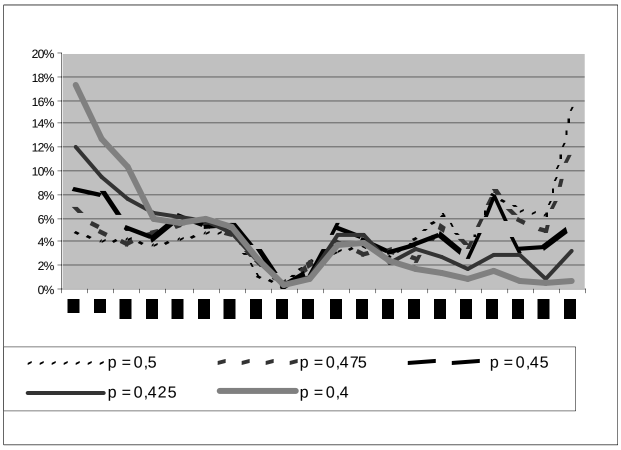

Figure 5b – Pivot distribution for set B (Table tennis)

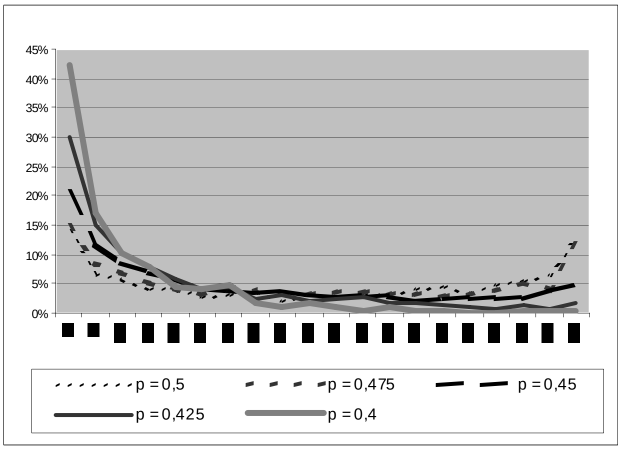

Figure 5c – Pivot distribution for set B (Basketball)

C – Equalities distributions

The equalities distribution show remarkable convergence between the three sports. Means, standard deviations and more noteworthily distribution curves look very much alike for set A (see table 6 and figure 6).

Table 6 – Equalities statistics for set A

	Tennis	Table tennis	Basketball
Mean	9,68	8,82	10,71
Std	6,91	6,14	7,57

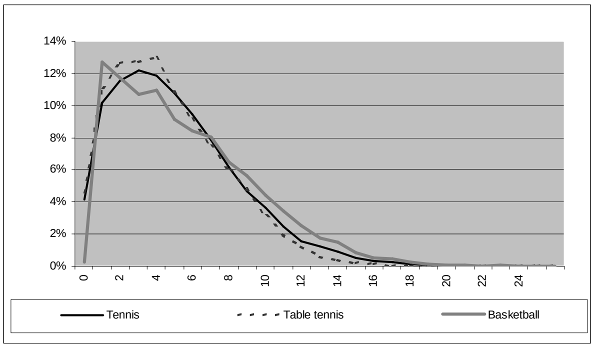

Figure 6 – Equalities distribution for set A

Aside from random variations due to the limited number of simulated matches, there is not much to comment about set B figures. Basketball, table tennis and tennis do not seem to vary significantly from one another on these criteria.

Table 7a – Equalities statistics for set B (Tennis)

	p = 0,5	p = 0,475	P = 0,45	p = 0,425	p = 0,4
Mean	9,58	8,97	7,33	5,21	4,18
Std	6,83	6,84	6,16	4,82	3,97

Table 7b – Equalities statistics for set B (Table tennis)

	p = 0,5	p = 0,475	p = 0,45	p = 0,425	p = 0,4
Mean	8,89	8,31	6,54	4,99	3,94
Std	6,17	6,25	5,45	4,73	4,10

Table 7c – Equalities statistics for set B (Basketball)

	p = 0,5	p = 0,475	p = 0,45	p = 0,425	p = 0,4
Mean	10,39	9,83	8,29	6,47	5,07
Std	7,43	6,98	6,59	5,61	4,43

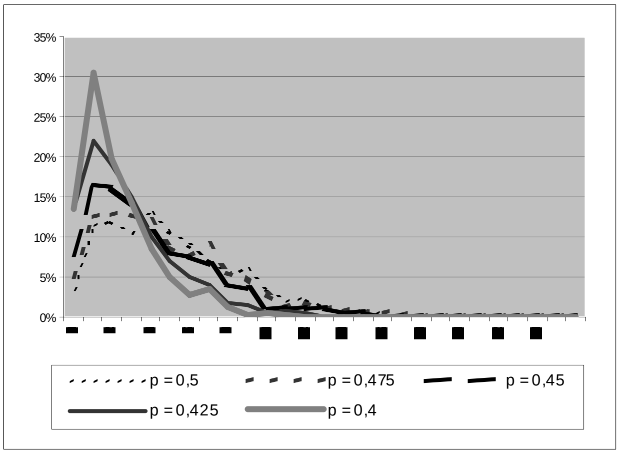

Figure 7a – Equalities distribution for set B (Tennis)

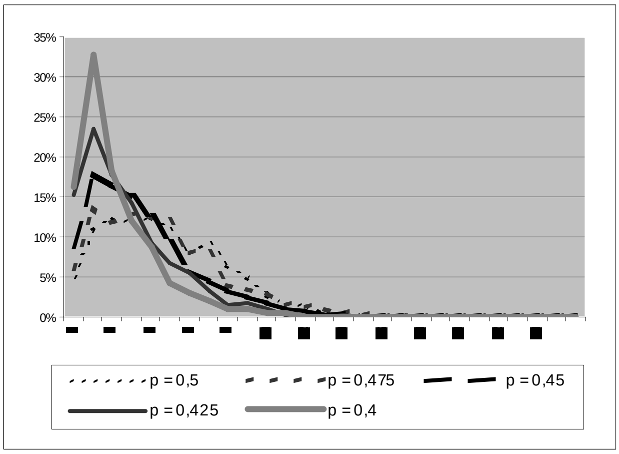

Figure 7b – Equalities distribution for set B (Table tennis)

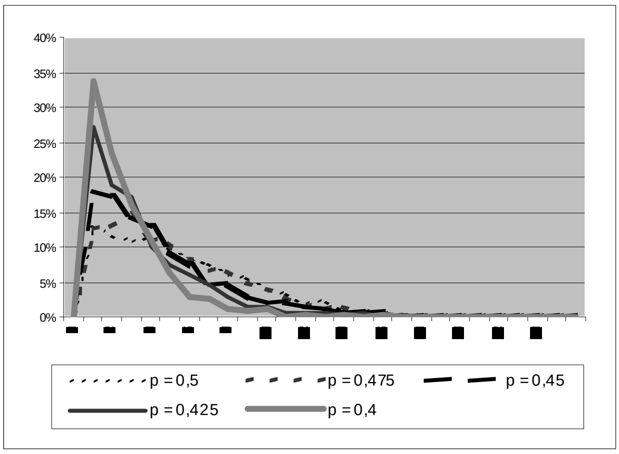

Figure 7c – Equalities distribution for set B (Basketball)

D – Immediacies distributions

Immediacies is a special indicator that need not be determined for basketball for in this case it is constant: the end of the match always happens at the official, known and predictable time.

As for tennis and table tennis, a match can stop more or less abruptly. In our Monte Carlo simulations, the shortest tennis match went to a total of 66 points whereas the longest lasted for 315 points, 4.8 times more (respectively 92, 223 and 2.4 for table tennis).

Simultaneously, immediacies seem a bit more frequent (and also more variable) in tennis than in table tennis. The mean values of 15.78 and 13.53 for set A (see table 8) should be compared to the minimum value of 5 (characteristic of the situation when the leader closes out the match as soon as he can).

These trends persist with the use of set B parameters. Tables and figures 9a and 9b show that even for an unequally balanced confrontation, a minimum level of suspense remains in that immediacies tend very slowly towards 5 (especially for tennis), resulting in a situation where anytime in the match, fans should not completely lose their hopes or attention.

Table 8 – Immediacies statistics for set A

	Tennis	Table tennis	Basketball
Mean	15,78	13,53	-
Std	10,73	8,02	-

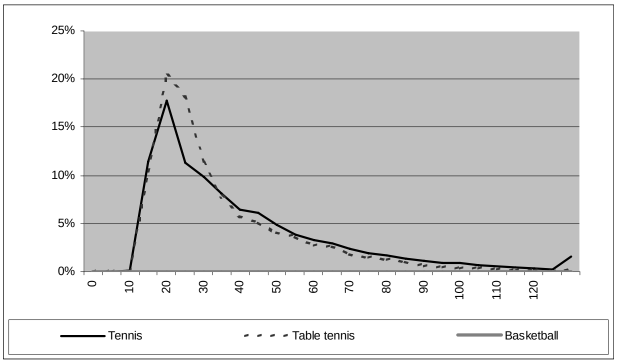

Figure 8 – Immediacies distribution for set A

Table 9a – Immediacies statistics for set B (Tennis)

	p = 0,5	p = 0,475	p = 0,45	p = 0,425	p = 0,4
Mean	15,37	15,61	13,54	11,58	10,41
Std	10,44	11,32	9,35	6,87	5,93

Table 9b – Immediacies statistics for set B (Table tennis)

	p = 0,5	p = 0,475	p = 0,45	p = 0,425	p = 0,4
Mean	13,62	12,56	11,16	10,05	9,00
Std	8,13	7,66	6,59	5,31	3,74

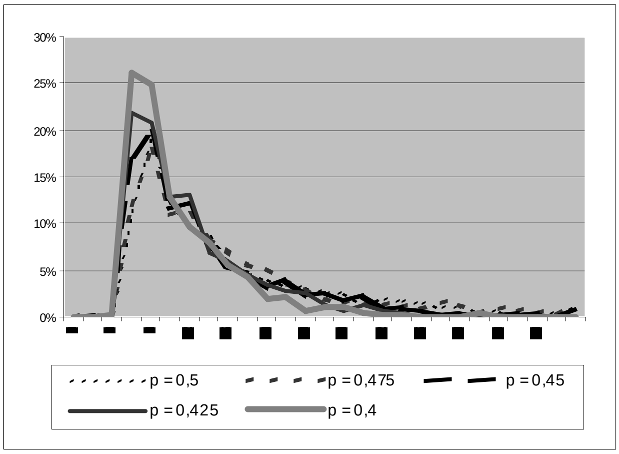

Figure 9a – Immediacies distribution for set B (Tennis)

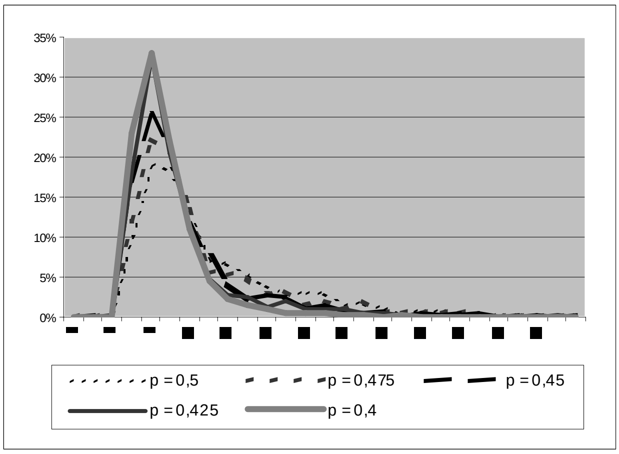

Figure 9b – Immediacies distribution for set B (Table tennis)

Conclusion

The conclusion we can draw from this series of experiments is that whereas basketball is more formatted, hence more suited for television programs, unpredictability in terms of length, capacity to turn around, and to come close to a possible end without necessarily actually closing are higher for table tennis and especially tennis.

This conclusion goes beyond a possible application to sports. It can lead to the development of a wider reflection about how suspense arises, not only in sports, but also in games, and especially in video games.

One of the obvious limits of this series of experiments is that it neglects some important factors such as:

- The advantage of serve in tennis or table tennis
- The feedback effect of the scoreboard on points winning probabilities (experience shows that better players tend to play well on important points)
- The extra-time situation in basketball
- Plus a number of psychological or physiological factors interfering with the rules in various sports.

In the future, we intend to present the results observed on the same measures operated on simulations run with parameters from set C, in order to investigate the capacity of score systems to reflect possible changes in matches momentums. After that, the next step could be either to replicate the research on a wider basis to assess the validity of the method and consolidate the findings, or to refine the simulating tools in order to take into account all the aforementioned factors that should be implemented into the model.

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