Challenges with the tennis challenge system

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Introduction

The new challenge system for close line calls in tennis has been used on the ATP and WTA tour for grand slam events since the 2006 US Open, and was designed to increase fairness for players by obtaining accurate line calls and enhance spectator interest through video technology. In the current system, players have unlimited opportunity to challenge, but once three incorrect challenges are made in a set, they cannot challenge again until the next set. If the set goes to a tiebreak game, players are given additional opportunities to challenge (usually one extra). If the match is tied at six games all in an advantage set, the counter is reset with both players again having a limit of up to three incorrect challenges in the next 12 games, and this resetting process is repeated after every 12 games.

Strategies as to when players should challenge have recently appeared in the literature. Pollard et al. (2010) show that challenge decisions are based on the rate at which challenges occur, the expected number of points remaining in the set, the number of challenges remaining in the set, the probability of the challenge decision being successful and the importance of the point to winning the set. Clarke and Norman (2010) apply dynamic programming to the challenge system to investigate the optimal challenge strategy and obtain some general rules.

There appears to be problems with the current challenge system:

- Firstly, both of the above articles show that early in the set a player needs to decide whether to challenge, or save challenges to later on in the set when the points are typically more important. Having to make such decisions is completely irrelevant to the game of tennis itself. The aim of the contest is to find the better player, and not to favour the player who is luckier within, or better at playing the challenge system. This is reflected by an article *Replay System Becomes Part of Players' Strategies* in The New York Times by Greg Bishop during the 2009 US Open.
  http://www.nytimes.com/2009/09/11/sports/tennis/11challenges.html

- Secondly, a player can run out of challenges because that particular set has a lot of balls that go close to the lines. This is perhaps particularly true in men's singles and men's doubles. The problem is exacerbated when each player does not have a similar number of challenges. A player who plays more balls near the lines is disadvantaged relatively. The player who, by chance has the need for more challenges, is disadvantaged.

- Thirdly, it would appear to be disappointing for the player and the spectators when that player runs out of challenges, the point is very important, and a challenge would have a clear likelihood of success. What is the chance that a grand slam final will be 'messed up' by an umpire making a wrong call and the player having run out of challenges, and subsequently losing the final when he might well have won it otherwise? This would be a very bad result for the player, the umpire and the game. Maybe this probability is not quite as small as some people might expect.

Importance of points

Morris (1977) defines the importance of a point for winning a game (I_{PG}) as the probability that the server wins the game given he wins the next point minus the probability that the server wins the game given he loses the next point. Table 1 gives the importance of points to winning the game when the server has a 0.62 probability of winning a point on serve, and shows that 30-40 and Ad-Out are the most important points in the game. In a similar way, we can define the importance of a game to winning a set and the importance of a set to winning a match. Table 2 gives the importance of games to winning a tiebreak set (I_{GS}) for player A serving. Player A and Player B were assigned point probabilities of 0.62 and 0.60 respectively to reflect overall averages in men's tennis. It is clear that every point is equally important for both players. Table 2 shows that the tiebreak game has the highest importance of 1.00, as the winner of this game wins the set. Similarly, table 3 gives the importance of sets to winning a best-of-5 set match (I_{SM}) and shows that the deciding set at 2 sets-all has the highest importance of 1.00, as the winner of this set win the match. Morris (1977) derived the following useful multiplicative result to obtain the importance of a point to winning the match (I_{PM}): For any point of any game of any set, $I_{PM} = I_{PG} * I_{GS} * I_{SM}$.

The definition of importance of a point in a match is a way of stating how much difference will result in the outcome of the match depending on whether a point is won or lost. In the context of a challenge system, importance of a point in a match can be viewed by how much percentage error will occur if a wrong decision is made. For example, suppose the score in a best-of-5 set match (all tiebreak sets) is 2-2 in sets, 5-5 in games and 30-30 in points and player A is currently serving. Suppose player A is winning 62% on serve and player B is winning 60% on serve. Using a Markov Chain model (Barnett and Clarke, 2005), player A has a 51.5% chance of winning the match from that position. If player A won the point, then his chance of winning the match would be 60.3%: whereas if player A lost the point then his chance of winning the match would be 37.3%. Therefore the importance of the point in the match is given as 60.3%-37.3%=23.0%. If a wrong decision was made at that particular point in the match, then it would cost one of the players 23 percentage points in their chance of winning the match.

	Receiver's score					
Server's score		0	15	30	40	Ad
	0	0.25	0.34	0.38	0.28	
	15	0.19	0.31	0.45	0.45	
	30	0.11	0.23	0.45	0.73	
	40	0.04	0.10	0.27	0.45	0.73
	Ad				0.27	

Table 1: Importance of points to winning a game when the server has a 0.62 probability of winning a point on serve

	Player B's score							
Player A's score		0	1	2	3	4	5	6
	0	0.29	0.29	0.22	0.18	0.06	0.02	
	1	0.26	0.32	0.33	0.21	0.16	0.03	
	2	0.25	0.29	0.36	0.37	0.20	0.11	
	3	0.13	0.27	0.33	0.42	0.43	0.14	
	4	0.08	0.11	0.30	0.38	0.52	0.54	
	5	0.01	0.06	0.08	0.34	0.46	0.52	0.53
	6						0.47	1.00

Table 2: Importance of games to winning a tiebreak set when player A and player B have a 0.62 and 0.60 probability of winning a point on service respectively and player A is serving

	B's score			
A's score		0	1	2
	0	0.36	0.42	0.32
	1	0.32	0.49	0.57
	2	0.18	0.43	1.00

Table 3: Importance of sets to winning a best-of-5 set match when player A and player B have a 0.62 and 0.60 probability of winning a point on service respectively

Proposed new challenge system

It is proposed that the present challenge rule is modified in one way. Namely, that a player is allowed to challenge on points with sufficiently large importance, without risking that player's challenge point total.

Suppose the threshold value on when a player can always challenge a line call was given by the importance of the point in the match at 2 sets-all, 3 games-all and player A serving. This is calculated as 0.247*0.420*1.00=0.104 when player A and player B have a 0.62 and 0.60 probability of winning a point on serve respectively. Then a player can always challenge at 2 sets-all and 3 games-all, only if the point score in the game has an importance of at least 0.247. This occurs at 30-40 or Ad-Out (I_{PG}=0.727), 15-40 (I_{PG}=0.451), 15-30 (I_{PG}=0.447), 30-30 or deuce (I_{PG}=0.446), 0-30 (I_{PG}=0.384), 0-15 (I_{PG}=0.341), 15-15 (I_{PG}=0.315), 0-40 (I_{PG}=0.279), 40-30 or Ad-In (I_{PG}=0.273) and 0-0 (I_{PG}=0.247). This is represented in table 4 for a range of game scores in the deciding set, where an X indicates that a challenge is always allowable by both players. Note that a player can challenge at 2 sets-all and 6 games-all (tiebreak game), only if the point score has an importance of at least 0.104. This occurs for the majority of points in the tiebreak game, as expected.

	Score line at 2 sets-all (player A serving)					
Point score	0-0	1-1	2-2	3-3	4-4	5-5
30-40 or Ad-Out	X	X	X	X	X	X
15-40	X	X	X	X	X	X
15-30	X	X	X	X	X	X
30-30 or Deuce	X	X	X	X	X	X
0-30	X	X	X	X	X	X
0-15		X	X	X	X	X
15-15			X	X	X	X
0-40				X	X	X
40-30 or Ad-In				X	X	X
0-0				X	X	X
30-15					X	X
15-0, 30-0, 40-15 or 40-0						

Table 4: Indication as to whether a player can always challenge on a particular point in a match for a range of game scores in the deciding set given that the threshold value is given as 0.104

References

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