4-15-2016

Discouragement, Gender, and Professional Tennis

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Submitted April 15, 2016

Introduction

Psychologists and economists assert that discouragement plays an important role in determining how individuals respond to adversity. For example, regions with high persistent unemployment are linked with higher numbers of discouraged workers who stop looking for work altogether (Sandmeyer and Larkin, 1970). A study by Dernberg and Strand also found that some groups who may have a harder time obtaining employment, such as women, the very old, and the very young show higher levels of labor discouragement during times of high unemployment (Dernberg and Strand, 1966). Similarly in the realm of education, biases favoring boys in elementary school can lead to discouragement among girls and negatively impact their achievement in middle and high school (Lavy and Sand, 2015). However, less is known about the role of discouragement in high stakes situations with professionals or experts. This paper asks whether professionals in high stakes scenarios are prone to costly discouragement in the context of professional athletic performance.

The world of competitive sports provides a unique and useful framework from which to examine the impact of discouragement in a non-experimental but controlled environment. Few other contexts allow researchers to observe experts in the field repeatedly with very rich data. For this paper, I will examine discouragement and psychological momentum in the context of professional tennis using a data set of more than 850,000 professional tennis matches from 1969 – 2015 and focus on player performance following a close loss, such as 5-7 loss, in the first set.

Previous research has shown that positive autocorrelation exists between past performance and future performance in competitive sports. In tennis, this would mean that winning a set increases the probability of winning the following set and vice versa for losing a set. This suggests that players remember events from past sets and that past sets influence future sets. Indeed research by David Jackson has shown that models that incorporate a "success-breeds-success" element better fit the data for the 1987 Wimbledon and US Open tennis tournament results than models that assume performance in sets or matches are independent (Jackson, 1993 & 1995). Research on team sports, specifically basketball, has also yielded similar results. A study by Mace, Lalli, Shea, and Nevin showed that collegiate men's basketball teams that performed well before the onset of adversity,

such as a turnover or personal foul, responded better post-adversity than teams who were performing poorly before the adversity (Mace, Lalli, Shea, Nevin, 1992). A follow up paper examined the same question but in the context of women's basketball and found that women exhibited similar behavior but to a lesser degree than men (Roane, Kelley, Trosclair, Hauer, 2004).

Though these results support the existence of psychological momentum, the notion that past results affect future results, they do not control for team and player ability. The higher ability level of better teams or players can in large part explain positive autocorrelation between past and future performance. For example, in the basketball studies, this may simply mean that more skilled teams respond better to adversity.

This paper seeks to control for player ability and isolate the results of psychological momentum from the results attributed to player ability. More importantly, by isolating situations that cause psychological momentum to potentially change, we can identify those situations in which players become discouraged.

In tennis, men typically play best out of five sets for major tournaments and best out of three sets for all other tournaments. Women play best out of three for all tournaments. Sets are won by winning 6 games with a at least a two game lead over the opponent. If both players have each won 5 games, then the first player to win the next to games, so 7 games total, wins the set for a score of 7-5. In the event that each player has won 6 games, the set goes into a tiebreak game in which the player who wins the tiebreak wins the set 7-6.

Discouragement in tennis can be characterized by losing the second set after losing the first set, the idea being that a loss in set 1 may discourage players and adversely affect their performance in following sets. We posit that certain ways of losing the first set give rise to discouragement, specifically losing a set 5-7 since such losses involve losing two straight games after being tied 5-5 with the opponent. Since 5-7 and 4-6 losses are identical in terms of serve breaks and game deficits – proxies for ability – we should expect to see performance after losing a set in either 5-7 or 4-6 scores to be identical if there is no discouragement. However, this is not what we find.

Data:

The study relies on match level data from professional men's and women's tennis matches from 1969-2015[1]. The data also includes player characteristics such as rank, age, country, and height. I restricted the data to a sample with the following criteria:

Matches with impossible scores were removed; examples of such include scores of 1-1, 7-0, 18-0, among many others. This includes matches that ended early or did not finish for whatever reason. Only matches with set scoring rules mentioned before were kept. An exception to this is the Wimbledon, which scores every set in the traditional tennis scoring system except for the final set which does not contain tiebreaks. I also restricted the data to only include matches in which the loser was subject to elimination from the tournament since the focus is on high stakes situations in which losing a match means elimination from the tournament. Thus round robin matches were removed. Lastly I restricted the sample to matches in which both players had at least 10 professional matches overall. Since the analysis is on professional tennis, this step was done to prevent semi-pro or fringe professional tennis players from skewing the analysis.

The final data set includes 857,365 total matches and 13,737 individual players. Characteristics of the data from a match level and player level can be seen in Tables 1 and 2:

Table 1: Match Level Data Summary (Matches from 1969-2015)

	All	Men	Women
Matches	857,365	527,258	330,107
5 Set Matches	18,953	18,953	0
3 Set Matches	838,412	508,305	330,107

[1] https://github.com/JeffSackmann

Table 2: Player Level Data Summary

	All	Men	Women
Count	13,737	7,867	5,870
Players With No Rank Listed	967	312	655
Avg Rank	774.47	852.77	661.03
Avg Top Rank	600.41	387.98	308.71
Avg Age	21.54	22.47	20.32
Share of US Players	0.12	0.12	0.12
Avg Matches Per Year	14.70	15.35	13.83

The average number of matches played per year for each player was 14.70 for the overall data set, 15.35 for men, and 13.83 for women. The average age for each player was 21.54 overall, 22.47 for men, and 20.32 for women. A small share of players had no ranking listed for them. Analysis that involves player ranks omits these players.

Empirical Strategy and Results

Recall that there are two ways that can affect how a player loses a set: by the difference in ability between him and his opponent (his opponent may simply be better) or through discouragement. We want to determine if the latter affects performance so a way to identify and control for relative ability is needed as well as a way to measure discouragement. Specifically, we want to see if losing a set 5-7 induces discouragement since in such losses the player battles his opponent to a tie of 5-5 before losing both of the following two games.

First note that the number of games a players wins in a set proxies his or her relative ability to his or her opponent. For example a player who loses 4-6 in a set is likely closer in ability and skill to his opponent than a player who loses 0-6 in a set. Games won as a proxy for relative ability is further supported by the fact that each potential set score has varying number of serve breaks won or lost. For example, in set scores of 0-6, the losing player's serve was broken three times by her opponent, giving her a net difference in serve

breaks of -3, whereas in 4-6 sets, the player breaks her opponent's serve twice and gets her serve broken three times for a net of -1. The number of service breaks won or lost is indicative of relative ability because professional tennis players are expected to win most of the games in which they serve. If they lose many games in which they served or win many games by breaking their opponent's serve, this suggests a disparity in ability. Thus, a player that has a net difference in serve breaks closer to zero is likely similar in skill and ability to her opponent. Table 3 shows how set score and net serve breaks won are related. We see that the closer a set is, the closer to zero the net serve breaks won becomes, indicating similar relative ability.

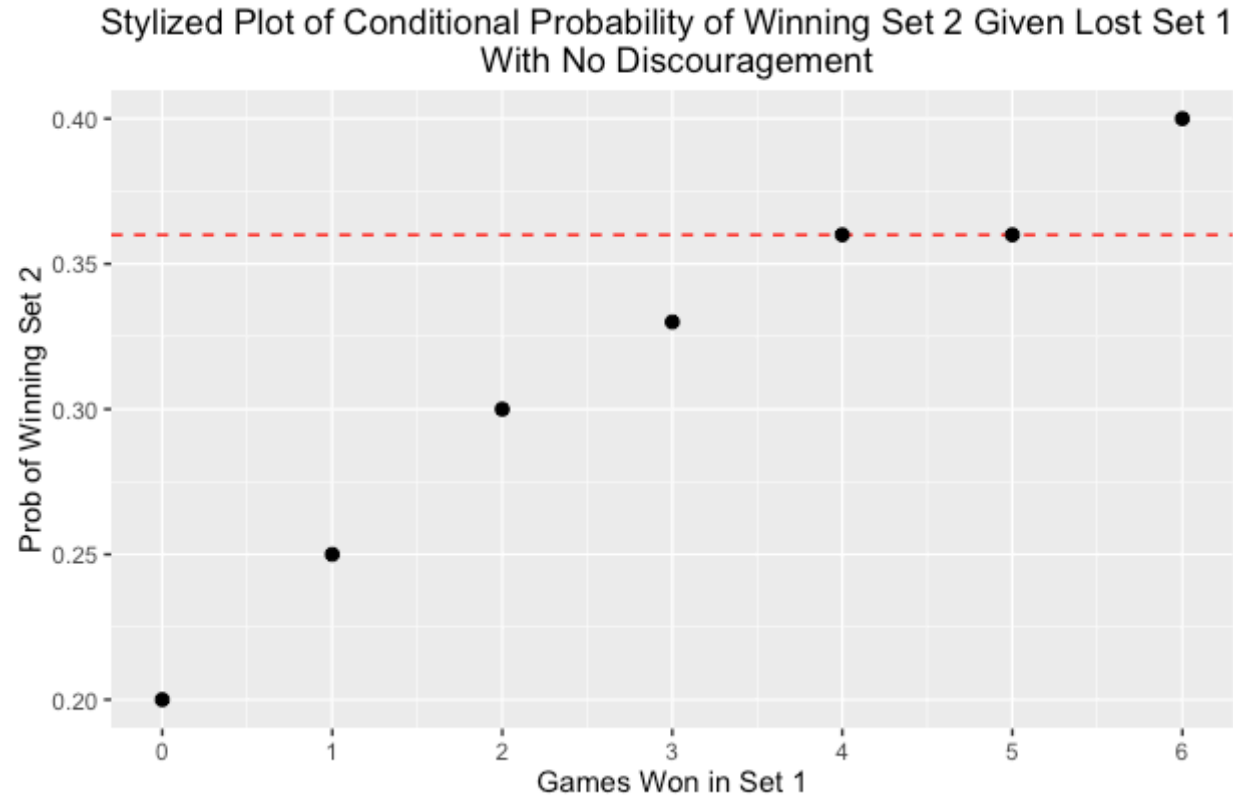
Table 3: Net Difference in Serve Breaks For Different Set Scores (From Loser's Perspective)

Set Score	0-6	1-6	2-6	3-6	4-6	5-7	6-7(TB)
Serve First	-3	-3	-2	-2	-1	-1	-1
Serve Second	-3	-2	-2	-1	-1	-1	-1

With an understanding of how set scores correspond to relative ability, we can predict the likelihood of winning set 2 given a loss in set 1 for different abilities, $\Pr(Win\ Set\ 2 \mid Lose\ Set\ 1)$. Thus, our measure for discouragement will be the probability of winning set 2 given a loss in set 1.

If there is no discouragement, we should expect to see the probability of winning set 2 given set 1 increase as we go from scores 0-6 to 4-6 since similarity in relative ability should be increasing. For scores of 4-6 and 5-7, we should see equal probabilities since both have equal game deficits (lost by two) and equal net serve break differences (-1) and should thus denote matches in which both players have equal relative ability. We should then see an increase for sets that go into tiebreaks since these players are theoretically the most close in ability. Figure 1 summarizes these expectations in a stylized plot; the red dashed line shows how losing 4-6 and 5-7 should have the same conditional probabilities if there is no discouragement.

Figure 1.



Results

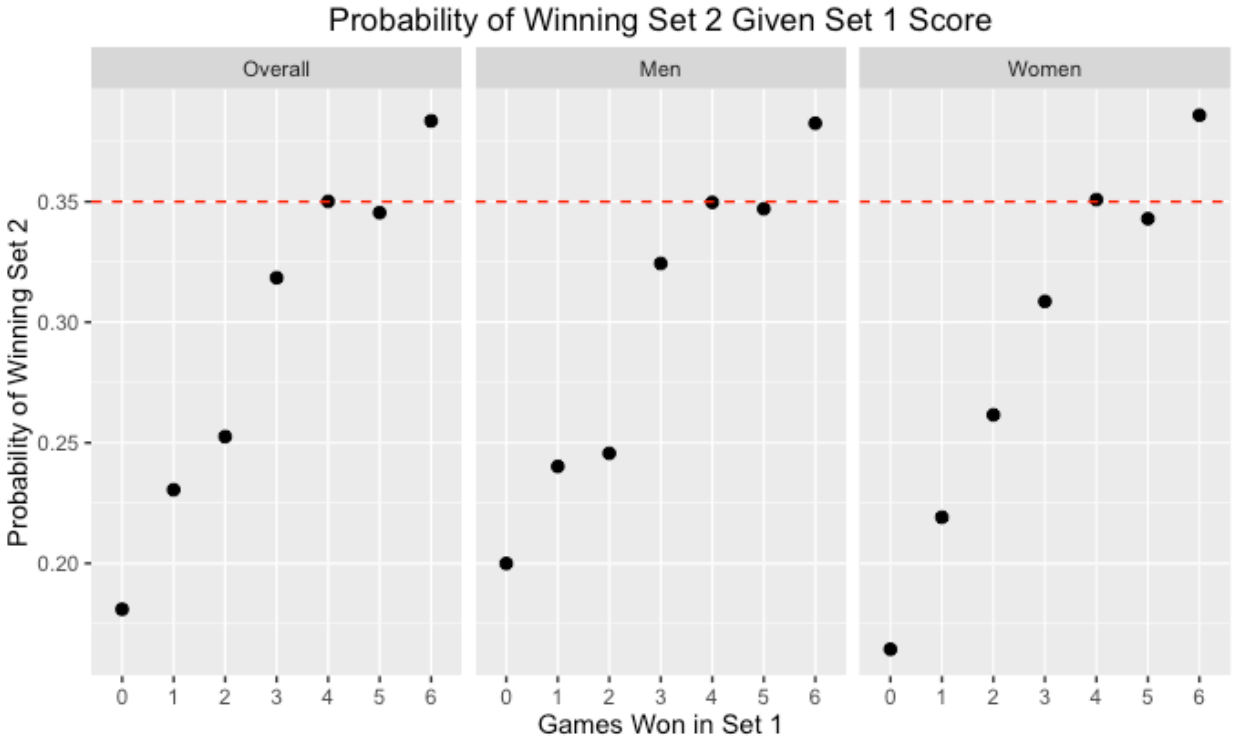
We now turn to analyzing actual match data. Table 3 below shows the average conditional probability of a player winning the second set after losing the first set for 3 set men's and 3 set women's matches. For simplicity, we restricted men's matches to those that were best out of 3 sets. The left most column on Table 3, labeled Set 1 Score, shows all the possible ways a player can lose the first set, with 6-7 indicating the player lost in a tiebreak. Standard errors were found by grouping observations into each possible set score and calculating the standard error of set 2 win outcomes (1 = win, 0 = lose) for each of those groups.

Table 3: Average Probability of Winning Second Set or Match Conditioned on Losing the First Set

	All			Men			Women		
Set 1 Score	Count	Prob Win Set 2	Prob Win Match	Count	Prob Win Set 2	Prob Win Match	Count	Prob Win Set 2	Prob Win Match
0 – 6	41,610	0.181 (0.385)	0.081 (0.272)	19,389	0.199 (0.400)	0.090 (0.286)	22,221	0.164 (0.371)	0.072 (0.259)
1 – 6	106,913	0.231 (0.421)	0.111 (0.315)	57,852	0.240 (0.427)	0.117 (0.322)	49,061	0.219 (0.414)	0.104 (0.306)
2 – 6	147,099	0.253 (0.434)	0.136 (0.342)	83,094	0.246 (0.430)	0.140 (0.347)	64,005	0.262 (0.439)	0.130 (0.337)
3 – 6	185,731	0.318 (0.466)	0.169 (0.375)	115,612	0.324 (0.468)	0.171 (0.377)	70,119	0.309 (0.462)	0.166 (0.372)
4 – 6	183,145	0.350 (0.477)	0.194 (0.395)	117,104	0.350 (0.477)	0.193 (0.395)	66,041	0.351 (0.477)	0.195 (0.396)
5 – 7	74,983	0.345 (0.475)	0.192 (0.394)	45,303	0.347 (0.476)	0.191 (0.393)	29,680	0.343 (0.475)	0.194 (0.395)
6 - 7	98,929	0.383 (0.486)	0.221 (0.415)	69,951	0.382 (0.486)	0.219 (0.414)	28,978	0.386 (0.485)	0.226 (0.418)

Table 3 shows a drop in win probability from set scores of 4-6 to 5-7 for the overall matches (0.005 decline), men's matches (0.003 decline), and women's matches (0.008 decline). We note that there is a small gender difference in that women appear to have a greater difference between their 4-6 and 5-7 outcomes compared to men. To better visualize this and the overall probabilities for the other set scores, Figure 2 plots these results.

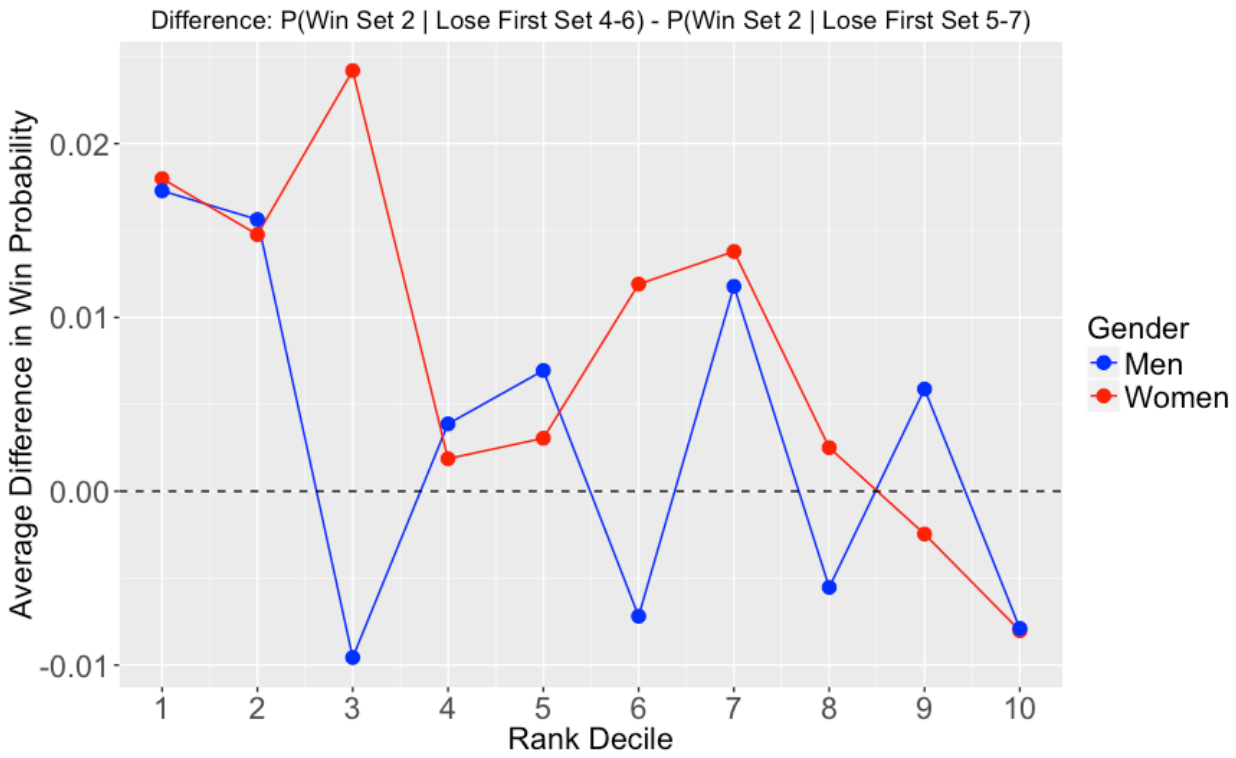
Figure 2:



The red dashed line shows where the probabilities for set scores of 4-6 and 5-7 would be if there is no discouragement effect. The fact that the conditional probability of winning set 2 after losing set 1 by 5-7 is less than the conditional probability of winning set 2 after losing set 1 by 4-6 is consistent with the possibility of discouragement taking place for players who lose the first set 5-7. We see that this effect is present for both men and women although it appears to be slightly stronger in women.

To understand how this effect might be modeled by player quality/experience, in Figure 3 we plot how the ranking of the player is associated with the results mentioned above. Specifically, the plot shows the difference in P(Win Set 2| Lose First Set 4-6) – P(Win Set 2 | Lose First Set 5-7). The horizontal dashed line shows where the differences in win probability should fall around if there is no discouragement since the win probabilities for 4-6 and 5-7 sets should be the same. We see that higher ranked players appear to have lower probabilities for 5-7 scores compared to 4-6 scores than lower ranked players. We also see that the effect tends to be stronger in women with more rank deciles having higher probabilities for 4-6 sets than 5-7 sets compared to men.

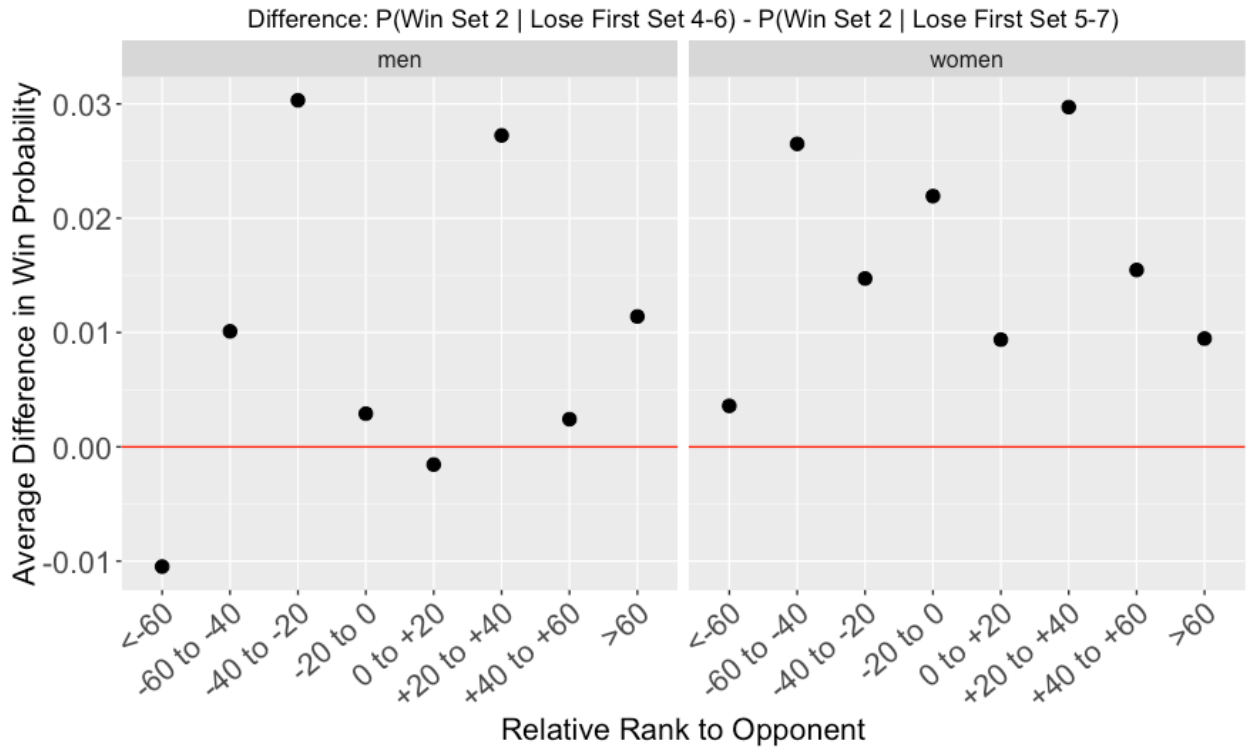
Figure 3.



In order to understand how relative ability between the player and his/her opponent models the effect, Figure 4 plots how the relative rankings of players is associated with the difference in second set win probabilities of 4-6 and 5-7 set 1 scores. The relative rankings plotted go from more than 60 ranks below the opponent, 60-40 ranks below the opponent, 40-20 ranks below, 20-0 ranks below, 0-20 ranks above, 20-40 ranks above, 40-60 ranks above, and more than 60 ranks above. The red horizontal dashed line shows where the differences in win probability should fall around if there is no discouragement since the win probabilities for 4-6 and 5-7 sets should be the same. However, we can see that for women, all relative rank categories have a difference in win probabilities that are greater than 0, which means the probability of winning the second set after losing the first set 4-6 is greater than the probability of winning the second set after losing the first set 5-7. This is consistent with the idea that discouragement is taking place for women who lose the first set 5-7. For men, we see some variation by relative rank in that for some relative ranks, the points fall below the red line. This is consistent with

results in Table 3 and Figure 2, which shows that the discouragement effect is potentially weaker for men than it is for women.

Figure 4.



Lastly, we run a linear regression with fixed effects to test the significance of the difference between 4-6 and 5-7 sets. The regression controls for player rank, opponent rank, relative rank, and round of the tournament while using fixed effects for year and individual players. The functional form used is:

$$P(Win\ Set\ 2) = a + \beta_1 rank + \beta_2 opponent.rank + \beta_3 relative.rank + \beta_4 1.game.won + \beta_5 2.games.won + \beta_6 3.games.won + \beta_7 4.games.won + \beta_8 5.games.won + \beta_9 6.games.won + \beta_{10} tournament.round$$

Note that relative rank is a categorical variable with the relative ranks categories used in Figure 4. Tournament round is also a categorical variable with the rounds being finals, semifinals, quarterfinals, round of 16, round of 32, round of 64, round of 128, and qualifiers. Table 4 shows the regression results for men and women. Table 4 only shows

the coefficient estimates for the possible set 1 scores. A full table showing the coefficients for all the other control variables can be found in the Appendix.

Table 4: Regression Output

	Men			Women		
	Estimate	Clustered S.E.	P-Value	Estimate	Clustered S.E.	P-Value
1. $game.won$	1.749e-02	4.027e-03	1.41e-05	3.288e-02	3.822e-03	2e-16
2. $games.won$	1.035e-02	3.836e-03	0.00699	6.090e-02	3.647e-03	2e-16
3. $games.won$	7.109e-02	3.829e-03	< 2e-16	9.298e-02	3.644e-03	2e-16
4. $games.won$	**8.606e-02**	**3.809e-03**	**< 2e-16**	**1.208e-01**	**3.852e-03**	**2e-16**
5. $games.won$	**8.380e-02**	**4.197e-03**	**< 2e-16**	**1.092e-01**	**4.357e-03**	**2e-16**
6. $games.won$	1.041e-01	4.076e-03	< 2e-16	1.409e-01	4.526e-03	2e-16

In Table 4, we can see that set score of 0-6 is omitted and used as the relative category. We also see that the probability of winning the second set given a loss in the first set by a score of 5-7 is lower than the probability of winning given a first set loss of 4-6. For men's the difference is 0.002 and for women's the difference is slightly higher at 0.003. Both of these estimates are also significant at an alpha level of 0.01. This is consistent with the possibility of 5-7 losses causing discouragement.

Conclusion

This study finds that performance after a 5-7 set loss in tennis is statistically significantly lower than a 4-6 set loss for both men and women despite these two scores being identical in terms of net difference in serve breaks and games deficit. If we accept the fact that set scores and net difference in serve breaks can serve as a proxy for ability, then 5-7 and 4-6 set scores should indicate similar ability between two players. Why then, are the outcomes different?

One explanation that can be inferred from the results is that a 5-7 loss is more discouraging than a 4-6 loss since the players were tied 5-5 at one point before the losing player lost two consecutive matches in a row. This discouragement effect then carries over into the following set and adversely affects the losing player's performance, thereby reducing his or her probability of winning the second set.

However, although discouragement is one explanation for this observed phenomenon, an alternate explanation could simply be fatigue. Players play two more games in 5-7 sets than they do in 4-6 sets, which could account for the decreased performance in the following set due to players being more tired. If two players are very similar in skill and ability, hence allowing them to play a close first set with a score of 5-7, but the only difference between them is that one player has slightly better physical conditioning than the other, then the effect we are witnessing here is once again driven more by physical ability rather than discouragement. Although we identified proxies for ability, perhaps our proxies do not capture marginal ability differences such as slight differences in physical conditioning that only show up when comparing 4-6 and 5-7 scores. This would also explain why the effect we found was stronger in women than in men since women may get more fatigued than men do after a close set.

To truly identify whether a discouragement effect is present in professional tennis, follow up studies would need to control for more marginal differences in ability such as physical conditioning. However, this study is a good building block for future potential studies by putting forth the idea of controlling for player ability when examining psychological momentum and discouragement and providing a method for capturing a large portion of individual ability differences through using net differences in serve breaks and set scores as a proxy for ability.

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Appendix:

Full Regression Output

	Men			Women		
	Estimate	Clustered S.E.	P-Value	Estimate	Clustered S.E.	P-Value
1. *game.won*	1.749e-02	4.027e-03	1.41e-05	3.288e-02	3.822e-03	2e-16
2. *games.won*	1.035e-02	3.836e-03	0.00699	6.090e-02	3.647e-03	2e-16
3. *games.won*	7.109e-02	3.829e-03	< 2e-16	9.298e-02	3.644e-03	2e-16
4. *games.won*	8.606e-02	3.809e-03	< 2e-16	1.208e-01	3.852e-03	2e-16
5. *games.won*	8.380e-02	4.197e-03	< 2e-16	1.092e-01	4.357e-03	2e-16
6. *games.won*	1.041e-01	4.076e-03	< 2e-16	1.409e-01	4.526e-03	2e-16
Rank	-3.338e-05	4.374e-06	2.31e-14	2.557e-05	8.717e-06	0.003350
Opponent Rank	1.895e-04	4.199e-06	< 2e-16	2.446e-04	7.664e-06	< 2e-16
More than 60 rank below	-7.264e-03	3.932e-03	0.06467	-2.763e-02	4.634e-03	2.50e-09
60-40 ranks below	-9.343e-03	4.835e-03	0.05331	-2.015e-02	5.389e-03	0.000184
40-20 ranks below	-4.972e-04	4.617e-03	0.91425	-1.528e-02	5.078e-03	0.002624
0-20 ranks above	3.687e-02	5.148e-03	7.99e-13	4.168e-02	5.812e-03	7.46e-13
20-40 ranks above	5.719e-02	5.208e-03	< 2e-16	6.504e-02	6.530e-03	< 2e-16
40-60 ranks above	7.517e-02	5.768e-03	< 2e-16	8.052e-02	6.680e-03	< 2e-16
More than 60 ranks above	8.118e-02	4.430e-03	< 2e-16	7.163e-02	5.566e-03	< 2e-16
Semifinal	-6.695e-03	4.859e-03	0.16830	1.788e-04	6.657e-03	0.978573
Quarter Final	-1.736e-03	4.493e-03	0.69931	6.118e-03	6.089e-03	0.314980
Round of 16	5.617e-03	4.341e-03	0.19572	9.700e-03	5.933e-03	0.102083
Round of 32	5.844e-03	4.305e-03	0.17469	1.644e-02	5.727e-03	0.004092
Round of 64	4.722e-03	5.590e-03	0.39824	4.651e-03	7.369e-03	0.528001
Round of 128	2.105e-02	1.391e-02	0.13017	5.554e-04	7.794e-03	0.943190
Qualifiers	5.297e-03	6.122e-03	0.38685	2.234e-02	6.396e-03	0.000478