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Is There Psychological Pressure in Competitive Environments?

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Is There Psychological Pressure in Competitive Environments?*

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Abstract. This paper provides laboratory evidence on the effect of psychological pressure in competitive environments. In our experiment, we analyze a setup of sequential tournaments, in which participants are matched in pairs and experience a kind of pressure that, as in most real world professional tasks, is not perceived as uncommon or exceptional. We do not find support for the first-mover advantage, while we obtain that second-movers perform significantly better under psychological pressure. Moreover we find that psychological pressure affects heterogeneously the performance of the subjects.

JEL Classification: D01, D81, C93.

Keywords: sequential tournaments, experiment, psychological pressure, competitive environments, first-mover advantage.

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1. Introduction

Competitive environments are the rule rather than the exception in markets. Economic agents compete for monetary gains and generally rules are clearly defined to determine winners and losers. For example, most incentive schemes are structured as contests, licences and patents are assigned through auctions, hiring or promotions frequently depends on formal contests. These tournaments are often not simultaneous but sequential, as two subjects are matched, they perform a task one after another, and the follower can observe the result of the first-mover. As illustrated by Kocher et al. (2011), this is easily the case in R&D races between companies, through preliminary research reports, political elections, through preliminary election polls, or labour market competitions, through intermediate steps of examination. In many cases, such sequential tournaments do not contemplate very high stakes and are experienced by a wide range of people. Although most of the economic literature on tournaments focuses on the provision of effort,[1] the analysis of individual performance in these environments has been recently the object of a wide debate about the psychological effects of competitive pressure.

To deal with this analysis, we implement an experimental setup in which subjects of a well defined pool are matched in all possible couples and orders, and in each match they have to compete for monetary payoffs, executing a task that they are used to. In this way, as in real life sequential tournaments between professionals, they are competing on a task that they are supposed to be good at, or at least well trained to perform.

In a randomized natural experiment, Apesteguia and Palacios-Huerta

[1] See Prendergast (1999) for a review of the theoretical literature, Charness and Kuhn (2010) for a summary of the experimental literature and Gill and Prowse (2012) for recent experimental evidence on sequential tournaments.

(2010) collect data on 129 penalty shoot-outs[2] in the major international soccer competitions and show that being first-mover significantly increases the probability of winning. They do not identify any psychological mechanism generating the result, but they interpret the finding as evidence that kicking second puts soccer players under psychological pressure. Their scoring probability would be lower because they are more likely to face the situation of lagging instead of that of leading in the partial score. This result might also be due to the reverse effect on the goalkeeper, whose performance would benefit from being second in the shoot-out. To refute this point, Apesteguia and Palacios-Huerta (2010) report regressions proving that goalkeeper's saves have a weaker impact on penalty outcome than kicker's misses, and a survey of Spanish professional and amateurs players, who mostly claim to prefer kicking first for the desire to put pressure on the opposing team. Kocher et al. (2011) check the robustness of this result on an expanded and comprehensive data set. They find that the probability of winning soccer shoot-outs for the first-kicking teams is not significantly different from 50% and conclude that "the first-mover advantage in sequential tournaments does not appear to be robust". Kolev et al. (2010) analyze data from the U.S. National Hockey League (NHL), where shootouts are used to break ties after overtime. They conclude that first-mover advantage is strictly related to scoring the first shot of the sequence. Conversely, starting the shootout and failing to score leads to the second-mover advantage.

This strand of literature assumes that shoot-outs in major tournaments are valuable data for understanding the impact of cognitive and emotional factors on real performance. Although external validity is highly desirable for

[2] Shootouts are used in soccer to determine the winning team in stages or finals of a tournament, after that extra time has been played. They are sequences of penalties kicked alternatively by different players of the opposing teams. Penalties are kicked from the penalty mark with the goal defended only by the opposing goalkeeper, but during a shoot-out players other than the kicker and the defending goalkeeper must remain in the field centre circle. In case the ball is saved by the goalkeeper, the kicker cannot score from the rebound, unlike a normal penalty kick.

evaluative research, the natural experiments under consideration present some drawbacks that should be addressed. First of all, they deal with competitive environments with strong affective impact and very high stakes. In shoot-outs most kickers experience extreme conditions of stress because they face a quite unusual task to be executed in exceptional circumstances such as international competitions.[3] Secondly, shoot-outs are competitions between soccer teams and the individual performance can depend on the social dynamics of the team. There is also empirical support to the idea that, in these situations, performance strictly depends on individual differences in cognitive anxiety. Dohmen (2008) provides evidence that German football players' performance in penalty kick situations is significantly affected by pressure variables such as the importance of success and the presence of spectators. Jordet et al. (2007) show that winning probability in soccer shoot-outs depends more on the degree of anxiety associated with the perceived importance of the kicks than on other factors, such as skill, physiology or chance. Gonzalez et al. (2011) analyze professional tennis players' performance proving that there is a marked heterogeneity in the reactions to changes in the importance of a point and this feature has a relevant impact on players' overall career.

These arguments explain why the evidence reviewed above is not applicable to very common situations in which stakes are not extremely high and competition is individual. In these types of contest, individual heterogeneity becomes the determinant key for the prediction of performance, as confirmed by many psychological studies. Since its inception, the relation between psychological pressure and sport performance has been studied within the framing of the so-called inverted U-hypothesis, which was first proposed by Yerkes and Dodson (1908). The theory assumes that individual performance is directly related to arousal until further arousal leads to a

[3] Penalty kicking is a specific task usually assigned to the team's specialist. For example, in the English Premier League 2009/2010, out of the 530 soccer players that played at least one game, only 49 (9%) kicked at least one of the 106 awarded penalties. Source: http://www.myfootballfacts.com/Premier_League_Stats.html

decline in performance. Hardy and Parfitt (1991) argue that, once the top level is reached, the inverted U-curve is not symmetric because performance drops drastically rather than gradually. This extreme situation has been identified as "choking under pressure" by Baumeister (1985), according to which excessive pressure makes performers focus attention on the task with the consequent attempt to drive consciously an automatized process. Typically, ways of coping with stress are idiosyncratic, heterogeneous and dependent on context (Carver and Connor-Smith 2010) and this makes it difficult to predict individual performance.

To gain insight on this issue, we design an experiment in which subjects compete in a task perceived as not exceptional nor rare. [4] To do it, we organize an individual free throw competition between pairs of basketball players, who are involved in a low-stake situation, in front of no audience, playing a 1-person game versus a team mate. The main characteristics of our design are the following. First, due to the rules of the sport, each player performs this task many times in a season under psychological pressure.[5] This implies that the experimental subjects are trained to face such situations. Therefore the evidence collected in our experiment is significant to analyze performance in most competitive tasks executed in real life.[6] Second, some of the most important confounding effects are excluded: because the outcome of the task depends only on the executing subject, and the payoff is individual and not for a team, by our design we can investigates the individual reaction to psychological pressure without any influence of other individuals and/or team dynamics. Finally, the complete sequences which we use to pair all subjects

[4] The previous literature examine performance in conditions of extremely high anxiety.

[5] The final result of many matches depends on the percentage of successful free throws.

[6] Hence, we cannot solve the dispute on whether extremely high tasks and high-anxiety conditions create a first-mover advantage, but we provide evidence on how to extend the analysis and its implications to lower stakes and milder psychological pressures.

allow us to analyze each subject in any situation of the sequential tournament, so that we always have multiple sources of control for the same subjects. Indeed our design adopts a sequence of throws different from soccer shoot-outs. While the kicking succession between two soccer teams, A and B, is ABABABABAB and ends when one team has scored more successful kicks than the opponent could possibly reach with all of its remaining kicks, our pairs of basketball players always complete the whole sequence AAAAABBBBB. In this way, second-movers can be in two different conditions: under psychological pressure, when they play shoots not useless to win the competition, or without psychological pressure, if shoots are useless. Therefore by our design is possible to conduct a within-subject comparison that allows us to analyze individual heterogeneity in the performance under psychological pressure.

Even if in our design, the second shooter tends on average to lag by a larger amount at the time he performs his tasks than in soccer shoot-out,[7] our results does not provide support for the first-mover effect. In contrast, we obtain that second shooters do significantly better when a throw is worthy and first shooter has scored many points compared to when they are playing as first shooter. On the other hand, second shooters do significantly worse when a throw is useless, compared to when they are playing as first shooters. Moreover, we are able to analyze individual heterogeneity in front of psychological pressure by observing the same player in different conditions. We identify three different types of players according to their performance and their response to different levels of psychological pressure, and we show that second shooter's performance strictly depends on belonging to one of these types.[8]

[7] We expect that this condition increases the disadvantage that, according to Apesteguia and Palacios-Huerta (2010), explains the first-mover effect, namely that "lagging behind" affects negatively second kicker's performance.

[8] As will be discussed in Section 3, the difference between two of the three types is

The rest of the paper is organized as follows. Section 2 presents the experimental design and compares its main features respect to previous studies. Section 3 provides a descriptive statistics and an econometric model that describes subjects' heterogeneity. Section 4 concludes.

2. Experimental design

We ran our experiment in September 2010 and September 2011 in two Italian towns with a strong tradition in basketball. The subjects were 57 male basketball players with age between 15 and 19, belonging to different teams. Players were randomly grouped in 9 distinct sessions (4 of 7 players,[9] 4 of 6 players and 1 of 5 players). In each session, every player faced twice every other player of the session in a one-to-one match of free throws, one time as *player 1*, the other as *player 2* (the distinction is defined below). The match in which two players met for the first time is called *match 1*, the one in which they met for the second time (in reversed order) is called *match 2*.

The rules of the matches were the following:

- player 1 shoots 5 free throws;
- then player 2 performs the same exercise;
- if one of the two has done strictly better, then he is the winner;
- otherwise, in case of a tie, they play tie-break: they try alternatively a throw each, up to the point that one player scores and the other misses the throw, so that a winner is decided.

A player received around 5€ in expectations for every won match, plus a participation fee of around 10€. Each session lasted approximately 2 hours. In total we collected 308 one-to-one matches, with 3080 "regular" free throws

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both in the overall performance and in the specific circumstances under which their performance increases (when they act as second shooters).

[9] Two of these 7-players sessions are those described in Feri, Innocenti and Pin (2011).

and 312 tie break throws: it resulted in almost 60 observations per player, with a minimum at 40 in the 5-players session.

To summarize and complement the considerations discussed above, our experimental setup has a number of nice features that make our study of interest comparing with the natural experiments analyzed by Apesteguia and Palacios-Huerta (2010), Kocher et al. (2011), and Kolev et al. (2010):

(i) it involves a competition using a task which all the participants are trained to perform under psychological pressure;

(ii) we analyze individual player's behavior and not team's performance;

(iii) the result of every single free throw depends only on its author and not on anyone else's performance (as a goalkeeper in soccer or hockey);

(iv) the individual performance only affects the individual payoff;

(v) the sequence of shoots is randomized and not chosen by the team trainer;

(vi) in the alternating sequence analyzed there, i.e. one shot each up to the point that one is the winner, all throws are worthy for the final result; in our design we can distinguish within-subject between worthy and useless throws and check how the performance changes with the stakes;

(vii) we have many additional sources of control, e.g. we can analyze the same couple of opponents twice, in both orders.

Finally, in terms of data analysis the main feature of our design is that it makes a clear distinction between first- and second-movers. We can analyze the aggregate performance of player *i* as second-mover, conditioning on the results of the first-movers he faces, and controlling on the behaviour of the same player *i* when he is first-mover. Free throws can be classified in two categories: "useless" (when the outcome of that throw is irrelevant in

determining winner and loser) and "worthy" (otherwise). It directly follows that while all throws of the first players and all tie break throws are worthy, the not tie-break throws of the second player can be distinguished in the two categories. Moreover, we distinguish the worthy throws into two sub-categories: the not tie break (when is not ambiguous we call them "worthy" or "regular") and the tie-break throws. We use this distinction because they differ in the situations they are executed and, consequently, in the intensity of psychological pressure. During the experiment, out of the 1540 regular free throws of second players, 332 throws were useless (hence, without psychological pressure) and 1208 were worthy and under psychological pressure.

Table 1: *Types of throws*

	Player		Total
Type of throw	1	2	
Useless	-	332	332
Worthy	1540	1208	2748
Tie-break	156	156	312
Total	1696	1696	3392

3. Results

In the following descriptive analysis, we test the significance of the observed differences using a t-test. We assume (as null hypothesis) that every single throw is an independent observation, so that the probability to score is independent from the past history, position to play, opponent and every other circumstance, i.e. the outcome of every single throw is randomly drawn from the same distribution.[10]

Table 2 shows that, when a player is second, the probability of scoring changes, depending on whether the throw is useless or worthy. On average,

[10] In the econometric analysis of the data introduced in the next subsection, we abandon any assumption of independence, relating any single throw to the player and to the circumstances.

when a throw is useless players do significantly worse, compared to worthy throws and compared to the overall performance when they act as player 1. Therefore, when a throw is useless, players seem to put less effort in execution respect to worthy throws. From another point of view, we can assume that the monetary incentives seem to have been effective in promoting a real effort in the proposed exercise.[11] Table 2 allows to check if players' position affects their performance. Overall, we find that there is no significant difference in the scoring rate between first and second player. This result is confirmed even if we focus on each type of throw (either tie-break or worthy).

Table 2: *Score rate by player position and type of throw*

	Player position	
Type of throws:	Player 1	Player 2
Useless	-	44.6
Worthy (tie break excluded)	**52.0	***53.6
Tie break	50.6	**55.8
All	**51.9	52.1

Note: ***, **, * denote significant difference with the score rate of useless throws (top-right) at the 1%, 5%, 10% level.

Now we explore if the absence of the effect of player position on the performance is due to the independence of players' performance (respect the position) or is the result of some hidden heterogeneous behaviour. While a subject acting as player 1 performs his exercise without knowing the (future) outcome of his opponent, a subject acting as player 2 observes the score of player 1. Therefore, while we could assume that the psychological pressure on a subject that acts as player 1 is homogeneous across matches and throws, this is not the case for a player acting as player 2. In order to explore how the psychological pressure affects the performance of a subject, we analyze how the scoring rate of player 2's worthy throws, excluding tie-break, changes as a consequence of the (observed) score of player 1. In Table 3 we can see that the

[11] Another robustness check is to analyze whether there have been arrangements between the players (even implicitly or unconsciously), driven by inequality or risk aversion. This check, which is provided in the appendix, discards this hypothesis..

score rate of player 2 is clearly increasing in the score of player 1. Even if the adjacent differences are not significant, we find this trend significant at 5% level[12] and a significant difference (at 5% level) of the score rate between worthy throws (but not a tie-break) after the first player has scored 3, 4 or 5 (56.4%), and all the other worthy throws (after player 1 has scored 0, 1 or 2, the score rate is 50.0%).

Table 3: *Score rate of player 2, (worthy throws excluding tie-break), by score of player 1*

Total score of the first player	Scoring rate %	(Number of throws)
0	43.2	(37)
1	49.7	(159)
2	50.9	(326)
3	55.9	(442)
4	56.5	(191)
5	60.4	(53)
Total	53,6	(1208)

We also find that the scoring rate of second players is significantly better in the 686 worthy throws (but not a tie-break) when the first player has scored 3, 4 or 5, compared to the score rate of player 1 in the not tie-break throws (respectively, 56.4 and 52.0%, difference significant at 10% level, p-value .055).

Exploring subject's heterogeneity

Now we explore if the experimental subjects are affected homogeneously by the psychological pressure that they face during the experiment. The effect of psychological pressure could vary across subjects, someone could benefit, others could be handicapped or be indifferent. We assume that there are three different types of subjects, indexed by $k = 1,2,3$, and that the probability to score throw i for player j being of type k is given by:

[12] By using the Cuzick trend test implemented in Stata.

$$P_{j,k,i}(1) = 1 - e_k + \delta_{w,k} d_{w,i} + \delta_{u,k} d_{u,i} + \delta_{t1,k} d_{t1,i} + \delta_{t2,k} d_{t2,i}$$

where e_k is a homogeneous probability of error, and *d's* are dummy variables defined in the following way: $d_{w,i}$ and $d_{u,i}$ take value 1 if throw i is executed by player 2 and, respectively, throw i is worthy but not tie-break, or throw i is useless, otherwise they take value 0; $d_{t1,i}$ and $d_{t2,i}$ take value 1 if throw i is executed by, respectively, player 1 or player 2, and it is a tie-break, otherwise they take value 0; $\delta_{w,k}$, $\delta_{u,k}$, $\delta_{t1,k}$, $\delta_{t2,k}$ are coefficients to estimate. These coefficients give us the change in scoring probability respect to not tie-break throws of subjects acting as player 1.

Let $x^j = \left(x_1^j, \dots, x_n^j\right)$ denote the (observed) outcome of the sequence of n_j throws by player j, where x_i^j takes value 1 if the i-th throw is scored, and otherwise takes 0. Then, the probability to observe x^j, conditional on player j being of type k, is given by:

$$P_{j,k}\left(x^j\right) = \prod_{i=1}^{n_j} P_{j,k,i}(1)^{r(i)} \left(1 - P_{j,k,i}(1)\right)^{1-r(i)},$$

where $r(i)$ takes value 1 if k-th throw is scored, otherwise 0.

Let π_k be the (prior) probability that a player is of type k, then the unconditional probability to observe a sequence of outcomes x^j is given by:

$$P_j\left(x^j\right) = \pi_1 P_{j,1}\left(x^j\right) + \pi_2 P_{j,2}\left(x^j\right) + \pi_3 P_{j,3}\left(x^j\right).$$

Let $x = \left(x^1, \dots x^j, \dots, x^{57}\right)$ denote the observed sequences of outcomes in the experiment, then the log-likelihood of the observed outcomes *x* is given by:

$$L\left(\left(e_k, \delta_{w,k}, \delta_{u,k}, \delta_{t1,k}, \delta_{t2,k}\right)_{k=1}^{3}, \pi_1, \pi_2 | x\right) = \sum_{j=1}^{57} \ln P_j\left(x^j\right).$$

The estimated parameters are reported in Table 4.

Table 4: *Model with heterogeneous players, estimated parameters*

	Coefficient	Standard error
$1 - e_1$***	0.338	0.028
$\delta_{w,1}$	-0.013	0.044
$\delta_{u,1}$	-0.120	0.079

$\delta_{t1,1}$	0.108	0.093
$\delta_{t2,1}$*	-0.146	0.078
$1-e_2$***	0.432	0.039
$\delta_{w,2}$**	0.106	0.043
$\delta_{u,2}$	0.022	0.075
$\delta_{t1,2}$	0.015	0.085
$\delta_{t2,2}$	0.010	0.089
$1-e_3$***	0.651	0.023
$\delta_{w,3}$	-0.019	0.028
$\delta_{u,3}$***	-0.143	0.045
$\delta_{t1,3}$	-0.076	0.065
$\delta_{t2,3}$***	0.142	0.053
π_1***	0.219	0.072
π_2***	0.317	0.098
π_3***	0.464	0.096
Log likelihood = -2269.038		

Note: ***, **, * denote significance at the 1%, 5%, 10% level.

The three types of subjects can be described in the following way:

Type 1. 22% of players are classified as this type. They have the worse scoring rate (34% of realization) and do significantly worse when they throw a tie-break as player 2;

Type 2. 32% of players belong to this type. They have a medium ability (scoring rate at 43%) and do significantly better as player 2 when the throw is worthy, but not when it is a tie-break.

Type 3. 46% of players are classified as this type. They have the best scoring rate (65% of realization) and do significantly worse as player 2 when the throw is useless and significantly better when they throw a tie-break as player 2.[13]

[13] The difference in ability between types 1 and 2 is significantly different only at the 10% level. Actually, if we run the same analysis constrained on two types instead of three, types 1 and 2 join together in a single type representing 54% of players, who performs slightly better when the throw is worthy. However, the Akaike information criterion tells us that the 3-types division is almost twice as likely, if compared with the 2-types division.

Assuming that the player 2's psychological pressure during the execution of tie-break throws is higher than during the execution of worthy non-tie-break throws, we could classify the three types according to the effect of the pressure on their performance. In the following, we call *medium (high) pressure* the situation in which a subject acting as player 2 executes a worthy not-tie-break (tie-break) throw. Therefore we can say that while type 1 is negatively affected by psychological pressure, types 2 and 3 react more positively. In detail, type 1 is unaffected by a medium level but his performance decreases with the high level. Type 2 is unaffected by a higher level of pressure but, for medium level, his performance improves. Finally, type 3 is unaffected by a medium level of pressure but a high level enhances its scoring rate. So the three types display an increasing ability to manage the high level of psychological pressure, type 1 is affected negatively, type 2 is indifferent and type 3 is affected positively. It is interesting that this ability to manage high levels of pressure is directly related to the scoring rate.

4. Conclusions

This paper has analyzed individual performance in competitive sequential tournaments. Differently from the empirical literature on shoot-outs in major tournaments, which investigates competitions in high anxiety conditions, we have designed a field experiment in which subjects performed a task that they are trained for. Our setting, an individual free throw competition between pairs of basketball players, represents a situation of lower anxiety, in which participants experience a form of psychological pressure that is not perceived as uncommon or exceptional. This feature allows us to provide evidence disentangled by the impact of individual heterogeneity, which is a key variable in coping with conditions of excessive stress, as claimed by psychological research on choking under pressure.

Our first result is that we do not find support for the first-mover advantage. In the aggregate there is no significant difference in the scoring

rate between first- and second-movers, also by considering only free throws that are worthy to win or lose. The psychological pressure of "lagging behind" does not affect negatively second-mover's scoring probability, which improves significantly when free throws are worthy than when they are useless and when first-mover's score is relatively higher. So, even if we started from a situation in which, according to previous explanations, a first-mover advantage should be observed, we obtain that second-mover performs significantly better under psychological pressure.

Our second finding shows that heterogeneity matters in competitive environments. We assess experimental subjects' performance in three distinct types that differ in the ability to manage high and medium levels of psychological pressure. This result supports the theory that individual performance in competitive environment depends on individual differences in cognitive anxiety.

Finally, we want to remark again that the characteristics of our experiment enhances the external validity of our findings to all the real competitive environments in which people perform a task which is familiar and stakes are not unnaturally high, and this makes our approach of broad empirical relevance.

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Appendix

Here, we check if there have been arrangements between players due to some form of inequality aversion: one player could have decided to lose the match 2 if he won match 1 with the same opponent, in order to equalize the expected payoff. In order to verify this hypothesis, we consider: a) the correlation between the results in matches 1 and 2 with the same opponent; b) the score rate of the worthy and non tie-break throws in all matches 2, conditional on the result in match 1 with the same opponent. We do not find any significant correlation between the result of the first and the second match with the same opponent and we find that, overall, the score rate in the second match is significantly higher for the winners of the first match (respect to losers) and this difference is driven by players 1 (see Table 2). This evidence excludes the hypothesis described above that outcomes could be affected by some form of inequality aversion.

Table 5: *Score rate in matches 2 by position and result in match 1 with the same opponent (worthy and non tie-break throws)*

	Result in match 1	
	Win	Lost
Player 1	***58.6	49.6
Player 2	51.9	54.2
All	*55.9	51.7

Note: ***, **, * denote significant difference across columns (left compared to right) at the 1%, 5%, 10% level.

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