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GENDER DIFFERENCES AND DYNAMICS IN COMPETITION: THE ROLE OF LUCK

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Gender Differences and Dynamics in Competition: The Role of Luck *

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Abstract

In a real effort experiment with repeated competition we find striking differences in how the work effort of men and women responds to previous wins and losses. For women losing per se is detrimental to productivity, but for men a loss impacts negatively on productivity only when the prize at stake is big enough. Responses to luck are more persistent and explain more of the variation in behavior for women, and account for about half of the gender performance gap in our experiment. Our findings shed new light on why women may be less inclined to pursue competition-intensive careers.

Keywords: Labor market outcomes; Gender gap; Experiment; Real effort; Career development; Competition; Productivity; Relative performance evaluation; Tournament; Luck; Wining; Losing.

JEL Classification: C91; D03; J16.

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1 Introduction

Incentive schemes based on tournaments, where workers compete for a prize or set of prizes, are ubiquitous in labor markets. Promotional tournaments are common in consulting, law partnerships, academia and industry. Firms frequently use bonus schemes based on relative performance evaluation. Academics compete for publications in top journals. Students compete in examinations to land better jobs. Workers in high-tech firms compete to develop the best innovations. Sports stars are paid bonuses by team owners for winning leagues and cup competitions. More generally, professional success and progression usually involves repeated competitive interactions in the form of multiple rounds of job applications and frequent assessments for internal promotions. The empirical relevance of competition-based compensation and promotion policies is evidenced by, for instance, Eriksson (1999) and Bognanno (2001) (and the references therein), while the seminal theoretical contribution of Lazear and Rosen (1981) elucidates many of the incentive properties of tournament-based pay. Establishing how workers actually respond to competition-based incentives and how these responses might vary by gender is thus crucial to understanding how labor markets work, how competition interacts with gender to determine labor market outcomes for men and women, how employers should design compensation schemes and how governments might regulate labor market transactions and institute possible affirmative action programs.

The contribution of this paper is to provide experimental evidence of how men and women respond to winning and losing when competition is repeated. In particular, and to the best of our knowledge, our paper is the first to report how the work effort of men and women responds to the outcome of previous competitions. In each of 10 rounds subjects are paired and informed of the value of the monetary prize that they are competing for, which varies randomly across pairings and over rounds. The prize, which can be interpreted as a relative-performance bonus, is awarded to one of the pair members depending on the relative work efforts of the pair members in the "slider task", which involves positioning a number of sliders on a screen, and some element of chance or random noise which we control. The design of our real effort task allows us to collect a finely gradated measure of productivity in each round, and hence allows us to construct a panel dataset detailed enough to estimate accurately the impact in a given round of winning and losing in previous rounds by gender. We look both at the pure response to winning and losing, and also at the response to a more nuanced notion of luck whereby winning is considered luckier the lower the subject's probability of winning, which in turn is given by the difference between the subject's own work effort and that of his or her rival.

Our results show that men and women differ significantly in how they respond to previous wins and losses. Notably, we find that for women losing when the prize is small instead of winning the same prize induces a considerable negative effect on work effort in the next round. However, we find no such effect for men. Furthermore, for women conditional on losing the level of effort in the next round is independent of the monetary value of the prize that the women failed to win. For men, on the other hand, conditional on losing the level of effort in the next round decreases in the size of the prize that the men failed to win. Thus, relative to winning the smallest prize, for women losing per se is detrimental to productivity in the next round, but for men a loss impacts negatively on productivity only when the prize at stake is big enough. Overall, responses to previous competitive outcomes explain about 11% of the observed variation in the work effort of women but only about 4% of the variation in the work effort of men, and the impact of wins and losses on later work effort is also more persistent for women.

Better understanding the source and dynamics of gender differences in competitive environments is of prime importance for making sense of the gender gap in labor markets and formulating appropriate policy responses. Altonji and Blank (1999) survey the large literature on the impact of gender on labor market outcomes and conclude that "a large share of gender differentials remain "unexplained" even after controlling for detailed measures of individual and job characteristics" (p. 3249). The gender gap is particularly stark at the top of the corporate hierarchy: Bertrand and Hallock (2001) find that only 2.5% of top U.S. executives are female, and that these female executives earn 45% less than their male counterparts. Arguably, competition for these top jobs is more intense than for lower or middle-ranking positions which pay less and are in greater supply. Our results suggest that the gender gap in labor markets may be driven partly by actual and anticipated responses to the process of winning and losing during competition, alongside more traditional explanations such as discrimination, ability differences and a stronger preference for investing in child-rearing.

In particular, our novel findings help to shed light on why women may choose to enter competitive work environments less frequently than men do and why they might underperform in such environments. Decomposition analysis shows that the differential responses by gender to wining and losing that we find account for about half of the gender performance gap that we observe in our experiment with repeated competition. Furthermore, our results suggest a new mechanism which may help to explain a greater reluctance on the part of women to compete: if the differential responses to winning and losing that we find are anticipated, women may indeed choose to enter tournaments less frequently than men and may thus be less inclined to pursue career opportunities which involve multiple rounds of competition for new positions, promotions and pay rises.

Our findings in a dynamic context thus complement the growing body of evidence of female competition aversion. This literature has not looked at how the work performance of men and women responds to previous competitive outcomes. However, recent research has documented that women are less likely to choose to enter a tournament, even after controlling for differential levels of confidence, risk aversion and aversion to feedback about relative performance (Niederle and Vesterlund, 2007).[1] Using Danish survey data, Kleinjans (2009) finds a link between a dislike for competition and occupational choice: women's stronger dislike for competition appears to decrease expected educational achievement and increase occupational segregation. A second strand of literature finds that the performance of women tends to deteriorate when they are forced to compete (e.g., Gneezy et al., 2003, Gneezy and Rustichini, 2004 and Ors et al., 2008).

If women dislike competition more than men do, an appropriate response by firms may be to reduce the degree of competition built into their pay and promotion structures. Why then do firms not implement such policies? Two explanations suggest themselves. First, men may fail to understand the extent to which women dislike competition and attribute too much of the difference in behavior across gender to ability differences and a lower preference for work relative to alternatives such as child-rearing. As men dominate top-ranking positions, they tend to shape pay and promotion structures, so the gender gap may become self-perpetuating. Second, it may be unprofitable to change the remuneration structure: firms may find it more efficient to operate highly competitive structures in order to induce high work effort while accepting that a lower female representation will result, especially at high rank and remuneration. The first explanation entails a role for government intervention on efficiency grounds and the second on grounds of equity.

Affirmative action programs to increase female representation can play a role under either scenario. In the first case, once female representation in higher-ranking positions improves, greater weight will be placed on the female dislike for competition when deciding pay and promotion policy. In the second case, the affirmative action may reduce efficiency but will improve equity across gender in society. Surprisingly, efficiency might not be impaired: Niederle et al. (2010) find that a quota system, whereby at least one of two winners must be female, causes many more high ability women to choose to enter a tournament so the average quality of the pool of entrants is hardly affected by the quota.

The rest of the paper is structured as follows: Section 2 describes the experimental design; Section 3 provides an overview of the data; Section 4 presents the econometric model and results; Section 5 discusses our results and concludes; Appendix A offers further robustness analysis; and Appendix B lays out the experimental instructions.

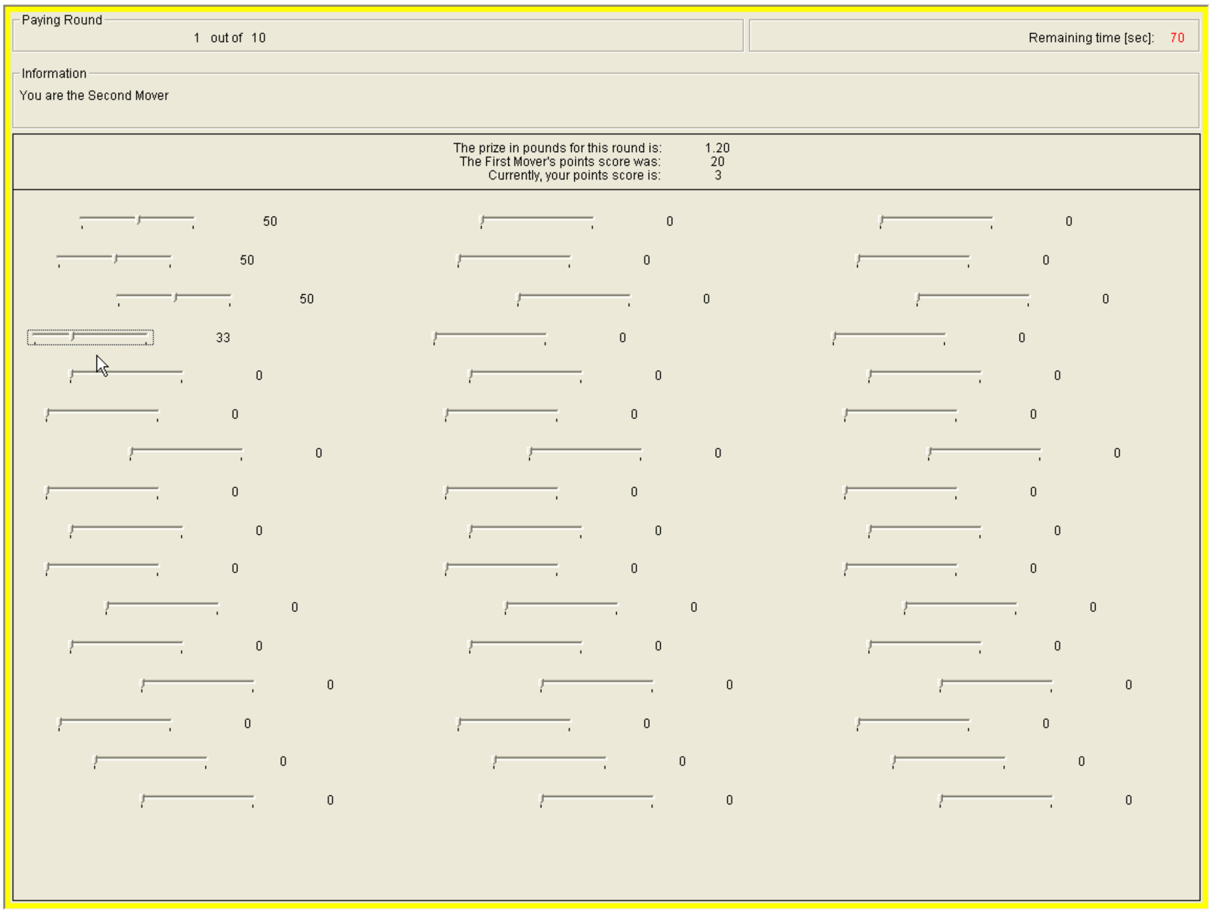
[1]For further supporting evidence, see for instance Gupta et al. (2005), Garratt et al. (forthcoming), Vandegrift and Yavas (2009), Cason et al. (2010) and Fletschner et al. (2010). However, Gneezy et al. (2009) find the same effect in a traditional patriarchal society, but not in a matrilineal one, while Charness and Villeval (2009) find no effect and Kamas and Preston (forthcoming) find differences only for business majors.

2 Experimental design

We ran 6 experimental sessions at the Nuffield Centre for Experimental Social Sciences (CESS) in Oxford, all conducted on weekdays at the same time of day in late February and early March 2009 and lasting approximately 90 minutes. 20 student subjects (who did not report Psychology or Economics as their main subject of study) participated in each session, with 120 participants in total. The subjects were drawn from the CESS subject pool which is managed using the Online Recruitment System for Economic Experiments (ORSEE). Gender played no role in the subject recruitment, and gender was not mentioned in the experimental instructions. At the end of each session, a screen appeared asking the subjects to report their gender. The experimental instructions (Appendix B) were provided to each subject in written form and were read aloud to the subjects. Each subject was paid a show-up fee of £4 and earned an average of a further £10 during the experiment (all payments were in Pounds sterling). Subjects were paid privately in cash by the laboratory administrator. The experiment was programmed in z-Tree (Fischbacher, 2007).

At the start of each session 10 subjects were selected at random and were told that they would be a "First Mover" for the duration of the session. The remaining 10 subjects were told that they would be a "Second Mover" for the entirety of the session. Each session consisted of 2 practice rounds followed by 10 paying rounds. In every paying round, each First Mover was paired anonymously with a Second Mover. The subjects were re-paired after every round using Cooper et al. (1996)'s rotation-based "no contagion" matching algorithm. Each pair's prize was chosen randomly from $\{£0.10, £0.20, ..., £3.90\}$ and revealed to the pair members. The First and Second Movers then completed our novel real effort "slider task" sequentially.

The slider task consists of a screen with 48 sliders. Each slider is initially positioned at 0 and can be moved using the mouse to any integer location between 0 and 100. Each slider has a number to its right showing its current position. A subject's "points score" in the task is the number of sliders positioned at exactly 50 at the end of 120 seconds. Figure 1 shows a screen of sliders as shown to the subjects in the laboratory. The slider task gives a finely gradated measure of performance and involves little randomness; thus we interpret a subject's point score as work effort exerted in the task. As the slider task gives a finely gradated measure of performance over a short time scale, we can construct a panel dataset detailed enough to allow robust statistical inference. Gill and Prowse (forthcoming) use the same dataset as here to test for disappointment aversion by looking at within-round responses to a rival's choice of work effort. See Charness and Kuhn (2010) for a discussion of the advantages and disadvantages of using real effort in labor market experiments.



Notes: The sliders were displayed on 22 inch widescreen monitors with a 1680 by 1050 pixel resolution. To move the sliders, the subjects used 800 dpi USB mice with the scroll wheel disabled. To ensure that all the sliders are equally difficult to position correctly, the 48 sliders are arranged on the screen such that no two sliders are aligned exactly one under the other.

Figure 1: Screen showing 48 sliders.

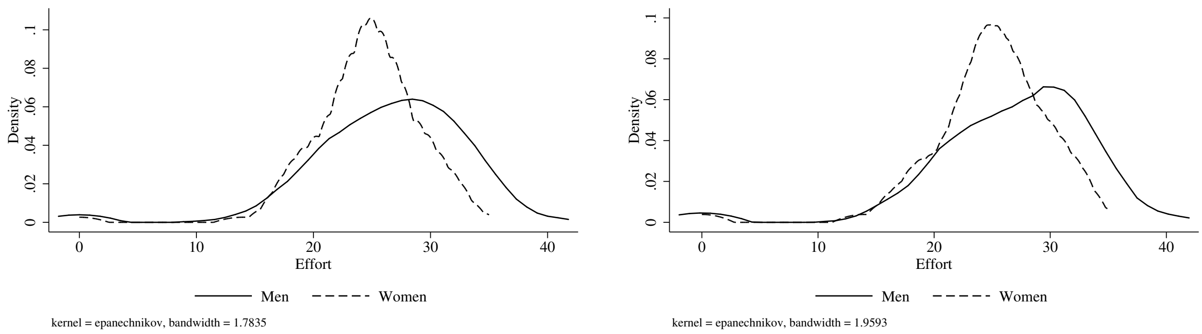
After the Second Movers completed the task, each pair's prize for the round was awarded to one of the pair members based on the points scores of the pair members and some element of chance. The probability of winning the prize for each pair member was 50 plus his or her own points score minus the other pair member's points score, all divided by 100 (so winning probabilities were linear in the difference of the points scores). The winner of the prize for each pair in every round was determined by a random draw uniform on $[0, 1]$: the First Mover won the prize if and only if the draw was lower than his or her probability of winning, and otherwise the prize was awarded to the Second Mover.

The Second Mover discovered the points score of the First Mover he or she was paired with before starting the task. During the task, a number of further pieces of information appeared at the top of the subject's screen: the round number; the time remaining; whether the subject was a First or Second Mover; the prize for the round; and the subject's points score in the task so far. At the end of the round, the subjects saw a summary screen showing their own points score, the other pair member's points score, their probability of winning the prize given the respective points scores, the prize for the round and whether they were the winner or loser of the prize in that round.[2]

3 Overview of the data

We start by providing an overview of the data. Throughout we analyze only Second Movers:[3] our sample consists of 30 male Second Movers and 28 female Second Movers observed completing the slider task in each of the 10 paying rounds (two Second Movers did not report their gender). The analysis focuses on behavior in rounds 3 onwards to allow for the effect on productivity of winning or losing in the two preceding rounds. Appendix A shows that there is no effect on work effort in a given round of winning or losing three rounds previously.

Figure 2 presents an initial summary of the raw data, split by gender. Effort choices range from 0 to 41. Figure 2(a) shows that the distribution of effort choices for men has a bigger right-hand tail than that for women, while Figure 2(b) shows that the effect persists during the second half of the experiment.



(a) Distributions of efforts for rounds 3-10.

(b) Distributions of efforts for rounds 6-10.

Figure 2: Distributions of effort choices.

The left-hand panel of Table 1 validates these observations: the proportion of women in the right-hand tail of the overall distribution of effort choices is significantly smaller than for men. For example, 75% of women's work efforts lie at or below the 60^{th} percentile of the effort

[2]In the practice rounds, the subjects were not told whether they had won or lost.

[3]We do not analyze data from the First Movers, who face a different situation to that of the Second Movers on a number of dimensions: (i) First Movers face a complicated strategic problem as they can influence Second Mover effort through their own choice, while Second Movers face a pure optimization problem (Gill and Prowse, forthcoming, show that the Second Movers do indeed respond to First Mover effort choices); (ii) First Movers start the task immediately after finding out whether they won or lost in the previous round, while Second Movers have time to internalize any psychological effects from winning or losing (while they wait for the new First Mover they have been paired with to complete the task); and (iii) First Movers find out what their probability of winning was at the same time as they discover whether they won or lost the round, while Second Movers choose their probability of winning during the task (as they know the effort of the First Mover they have been paired with).

distribution (the proportion is significantly greater than for men at the 5% level) and 92% lie at or below the 80$^{\text{th}}$ (significantly greater than for men at the 1% level). The right-hand panel of Table 1 shows that these distributional differences are persistent, as suggested by Figure 2(b).

	Rounds 3-10				Rounds 6-10			
	Men	Women	Difference	SE	Men	Women	Difference	SE
Mean effort	26.383	24.580	1.803	1.192	26.747	24.879	1.868	1.345
P(Effort $\leq Q_{20}$)	0.217	0.243	-0.026	0.084	0.221	0.243	-0.023	0.083
P(Effort $\leq Q_{40}$)	0.375	0.509	-0.134	0.104	0.369	0.509	-0.141	0.116
P(Effort $\leq Q_{45}$)	0.411	0.583	-0.172	0.107	0.401	0.584	-0.183*	0.110
P(Effort $\leq Q_{50}$)	0.451	0.656	-0.205**	0.100	0.435	0.644	-0.209**	0.104
P(Effort $\leq Q_{55}$)	0.486	0.706	-0.220**	0.094	0.474	0.702	-0.227**	0.103
P(Effort $\leq Q_{60}$)	0.525	0.750	-0.225**	0.091	0.521	0.758	-0.237**	0.097
P(Effort $\leq Q_{80}$)	0.742	0.919	-0.178***	0.057	0.748	0.914	-0.166**	0.066
Observations	240	224	-	-	150	140	-	-

Note 1: *,** and *** denote, respectively, significance at the 10%, 5% and 1% levels (2-sided tests). Standard errors are bootstrapped allowing clustering at the subject level.
Note 2: P(Effort$\leq Q_j$) denotes the proportion of observations at or below the j^{th} percentile of the distribution of effort choices, pooled over men and women. The j^{th} percentile is defined as the smallest effort level such that j% or more of observations lie at or below this level: because effort is discrete, we can therefore have P(Effort $\leq Q_j) > j$%.

Table 1: Descriptive analysis of effort choices of men and women.

The tendency for women not to exert high levels of effort is so strong that 66% of women's work efforts lie at or below the median, and men complete 1.8 sliders more than women on average (see the left-hand panel of Table 1). Figure 3 shows round by round mean efforts by gender: men complete more sliders on average in every round.[4] Significance tests provide support for this gender performance gap: Table 1 reports that the proportion of women's work efforts at or below the median is significantly greater than for men at the 5% level (for rounds 3 onwards and for rounds 6 onwards); and a likelihood-ratio test shows that, jointly, the means and variances of the distributions of work effort split by gender are significantly different from each other (rounds 3 onwards: $p = 0.007$; rounds 6 onwards: $p = 0.027$).[5] However, the mean performance difference of 1.8 sliders alone is not quite significant at conventional levels (as outliers cause the variance to be high).

[4]The gender difference in mean effort might change over rounds due to differences in learning by gender and due to differential responses to winning and losing in earlier rounds. Our empirical model includes both effects.

[5]This likelihood ratio test assumes that effort is the sum of a deterministic component and normally distributed transient and permanent unobserved heterogeneity. The unrestricted likelihood allows the mean of effort, and also the standard deviations of both the permanent and transitory unobservables, to vary by gender.

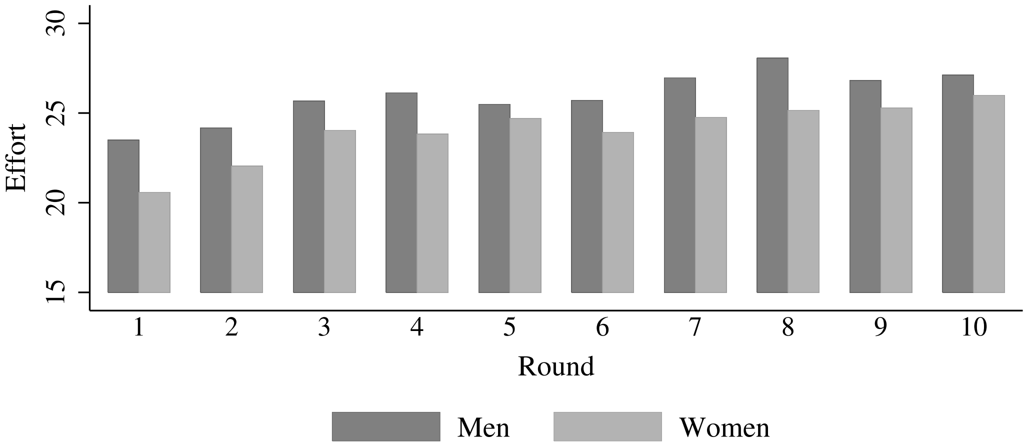


Figure 3: Round by round mean effort choices.

4 Empirical analysis

What factors might help to explain the differences in work effort by gender outlined in Section 3? Clearly, men and women may differ in average ability. In this paper, we focus on a further explanation: men and women may respond differently to good and bad luck. In particular, we look for gender differences in how Second Movers respond to whether they won or lost the previous two rounds of competition.[6] We first outline our model of behavior and discuss the estimation strategy, and then report the results of the analysis.

4.1 Model and estimation strategy

We model behavior for rounds 3 onwards to allow for the effect on productivity of winning or losing in the two preceding rounds. Specifically, for males, work effort in the r^{th} round for the n^{th} Second Mover, $e_{n,r}$, is given by

$$e_{n,r} = \sum_{j=1}^{2} \left(\beta_j^M L_{n,r-j} + \gamma_j^M W_{n,r-j} \times v_{n,r-j} + \theta_j^M L_{n,r-j} \times v_{n,r-j}\right) + \kappa^M v_{n,r} + \delta_r^M + \mu_n + u_{n,r}, \quad (1)$$

and for female Second Movers $e_{n,r}$ is given by the same expression replacing each M (for male) with F (for female).

In (1) $L_{n,r-1}$ is a dummy variable which takes a value of 1 if the n^{th} Second Mover lost in the previous round and zero otherwise. $W_{n,r-1}$ is the equivalent dummy variable in the case of a win. $L_{n,r-2}$ and $W_{n,r-2}$ are dummy variables for losing and winning two rounds previous to round r. Given the method of determining the allocation of each pair's prize in each round

[6] As we will see in Table 2, measuring luck in terms of monetary winnings relative to what was expected does not materially affect our results. Footnote 3 explains why we focus on Second Movers. As outlined in Appendix A, we found no evidence that behavior in a given round was affected by winning or losing three rounds previously.

described above in Section 2, the values of these dummy variables depend partly on the relative work effort of the pair members, and partly on luck, in the form of the random draw.

$v_{n,r}$ represents the prize that the n^{th} Second Mover was competing for in the r^{th} round. We interact the dummy variables for winning and losing with the relevant prizes to allow for the fact that the impact of winning or losing might depend on how much was won or on how much could have been won. We also include dummy variables for losing without a prize interaction to determine the impact of losing rather than winning independent of the prize.[7]

The inclusion of the κ^M and κ^F terms controls for any effect of the current prize on behavior. δ_r^M and δ_r^F are round specific intercepts, which control for differential learning and average ability by gender. μ_n is a round invariant subject-specific fixed effect, which allows for residual heterogeneity in ability across subjects that is not picked up by the gender and round specific intercepts. Lastly, $u_{n,r}$ is an unobservable that varies over rounds and over Second Movers and captures differences between rounds in a Second Mover's effort choice that cannot be attributed to the other terms in the model. $u_{n,r}$ is assumed to have mean zero and to be uncorrelated over individuals.

The above constitutes a dynamic linear panel data model. By construction, the fixed effect μ_n impacts on previous efforts, and therefore on previous winning and losing (as individuals with high effort in an earlier round are more likely to have won the prize in that round), and also affects current effort. Hence, the error term $(\mu_n + u_{n,r})$ is correlated with previous winning and losing, and it follows that the OLS estimates of the parameters in (1) will be inconsistent. We obtain consistent parameter estimates by using panel data Generalized Method of Moments techniques (see Arellano and Bond, 1991 and Holtz-Eakin et al., 1988, and also Bossaerts et al., 2007, for an application of Generalized Method of Moments in an experimental setting). Specifically, taking first differences of (1) gives

$$\begin{aligned}\Delta e_{n,r} &= \sum_{j=1}^{2} \left(\beta_j^M \Delta L_{n,r-j} + \gamma_j^M \Delta \left(W_{n,r-j} \times v_{n,r-j}\right) + \theta_j^M \Delta \left(L_{n,r-j} \times v_{n,r-j}\right)\right) + \\ &\quad \kappa^M \Delta v_{n,r} + \Delta \delta_r^M + \Delta u_{n,r}, \quad \text{for} \quad r = 4, ..., 10, \qquad (2)\end{aligned}$$

and an analogous equation can be written for females. First differencing therefore eliminates the subject-specific fixed effects. However, a further endogeneity problem arises in the first differenced equations because the transformed error term $\Delta u_{n,r}$ is correlated with the dummy variables for winning or losing in round $r-1$ (due to the correlation between $u_{n,r-1}$ and $e_{n,r-1}$ and therefore between $u_{n,r-1}$ and winning and losing in the previous round).

[7] We do not include dummy variables for winning without a prize interaction as the dummy variables for winning and losing are co-linear.

Similarly to Ham et al. (2005), we exploit randomization induced by the experimental design to obtain a number of valid instruments for the variables measuring the previous competitive outcomes in the first differenced equations: first, we use the random draws which determine whether the n^{th} Second Mover won the prize in the three rounds prior to round r; second, we use the random prizes in these earlier rounds; third we use the random draw interacted with the random prize for each of these earlier rounds; and fourth we use the effort choice of the n^{th} Second Mover's rival in these earlier rounds. Furthermore, we use the n^{th} Second Mover's own effort two and three rounds prior to round r, which under the assumption of zero serial correlation in $u_{n,r}$ are valid instruments (see footnote 12 for evidence supporting the assumption that $u_{n,r}$ is serially uncorrelated). All these instruments are also interacted with a dummy variable for the subject being male.[8] Appendix A shows that our results are robust to dropping various subsets of these instruments.[9]

4.2 Description of results

We start by reporting our parameter estimates and the associated behavioral effects. We then consider whether our results can explain part of the gender difference in work efforts described in Section 3.

4.2.1 Parameter estimates

Table 2 presents the estimated parameters for our preferred specification (that is the model outlined in Section 4.1). Figure 4 shows how these parameter estimates translate into behavioral effects of the competitive outcome in the preceding round on current effort provision.

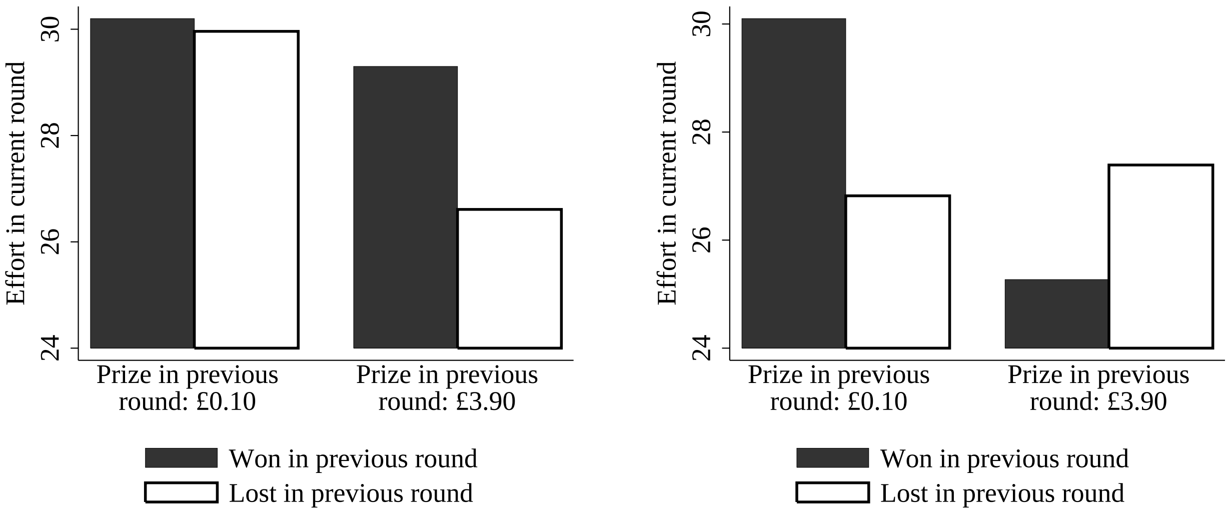
[8] To limit instrument proliferation, we collapse the instrument set by applying each instrument to all available rounds jointly. Although competitive outcomes dated $r-2$ are not endogenous with respect to the first difference of the transitory errors, we instrument for these variables in the same way as for competitive outcomes dated $r-1$ in order to maintain consistency. Our results are robust to this method of identifying the coefficients on competitive outcomes dated $r-2$. We identify the gender-specific current prize effects and the round-by-round changes in the gender-specific intercepts using standard orthogonality conditions based on the first differenced errors and the current prize and round dummies, and interactions of these variables with gender. Finally, we form two moment conditions based on the level equations for men and women, and these moments allow us to identify the level of the gender-specific intercepts.

[9] We have also checked that our results are robust to including contemporaneous First Mover effort and First Mover effort interacted with the prize as explanatory variables.

	Preferred Specification		Robustness to Measure of Luck	
	Estimate	SE	Estimate	SE
β_1^M (Lost round $r-1$; Men)	-0.093	0.836	-0.424	0.809
β_2^M (Lost round $r-2$; Men)	-3.093	2.213	-2.922	2.262
β_1^F (Lost round $r-1$; Women)	-3.499**	1.611	-3.169**	1.613
β_2^F (Lost round $r-2$; Women)	-2.271*	1.340	-2.121	1.367
γ_1^M (Won round $r-1$ × Prize in round $r-1$; Men)	-0.201	0.273	-0.333	0.529
γ_2^M (Won round $r-2$ × Prize in round $r-2$; Men)	-0.773	0.733	-1.584	1.456
γ_1^F (Won round $r-1$ × Prize in round $r-1$; Women)	-1.299**	0.570	-2.259**	1.132
γ_2^F (Won round $r-2$ × Prize in round $r-2$; Women)	-1.057**	0.491	-1.854*	0.999
θ_1^M (Lost round $r-1$ × Prize in round $r-1$; Men)	-0.847**	0.431	-1.254**	0.549
θ_2^M (Lost round $r-2$ × Prize in round $r-2$; Men)	0.071	0.417	-0.025	0.731
θ_1^F (Lost round $r-1$ × Prize in round $r-1$; Women)	0.168	0.257	0.294	0.501
θ_2^F (Lost round $r-2$ × Prize in round $r-2$; Women)	0.125	0.502	0.292	0.988
δ_{10}^M (Intercept in round 10; Men)	30.248***	2.110	30.139***	1.880
δ_{10}^F (Intercept in round 10; Women)	30.370***	1.945	29.811***	1.993
R^2	0.739		0.738	
R^2 (Men only)	0.772		0.773	
R^2 (Women only)	0.654		0.652	
Partial R^2 (due to winning and losing effects)	0.061		0.057	
Partial R^2 (due to winning and losing effects; Men only)	0.041		0.036	
Partial R^2 (due to winning and losing effects; Women only)	0.105		0.103	
Hansen test (df, p value)	20.681 (16, 0.191)		23.299 (16, 0.106)	
Observations	464		464	

Note 1: *,** and *** denote, respectively, significance at the 10%, 5% and 1% levels (2-sided tests). Standard errors are robust to heteroskedasticity and allow clustering at the subject level.
Note 2: The estimates of the contemporaneous prize effects (κ^M and κ^F) and of the intercepts (δ_r^M and δ_r^F) for rounds 3 to 9 are not reported in the table. The prize effects do not differ significantly by gender.
Note 3: Letting $P_{n,r-j}$ represent, in proportionate terms, the n^{th} Second Mover's probability of winning the prize in round $r-j$, the robustness to the measure of luck replaces $\gamma_j^M W_{n,r-j} \times v_{n,r-j}$ with $\gamma_j^M W_{n,r-j} \times v_{n,r-j} \times (1 - P_{n,r-j})$ and $\theta_j^M L_{n,r-j} \times v_{n,r-j}$ with $\theta_j^M L_{n,r-j} \times v_{n,r-j} \times P_{n,r-j}$ for males, and similarly for females. Luck is then measured in terms of monetary winnings relative to expectations. Because, on average, $P_{n,r-j} = 0.5$ the coefficients in this alternative specification tend to be higher.

Table 2: Estimated parameters.



(a) Men. (b) Women.

Notes: The effects are presented for the average male and the average female in round 10, ignoring the contemporaneous prize effect and the impact of winning and losing two rounds previously (by setting $\kappa^M = \beta_2^M = \gamma_2^M = \theta_2^M = 0$ for males, and similarly for females). Thus, after winning the effort for men is given by $\gamma_1^M \times v + \delta_{10}^M$ and after losing it is given by $\beta_1^M + \theta_1^M \times v + \delta_{10}^M$, and similarly for females. Alternative assumptions would shift the bars for men up or down relative to those for women.

Figure 4: Graphical description of impact of winning or losing in previous round.

The large negative estimate of β_1^F, which is significantly different from zero (2-sided $p = 0.030$), indicates a strong negative impact on current work effort for a woman of having lost in the previous round independent of the value of the prize that she failed to win. However, we find no such effect for men (β_1^M is close to zero and not significant). Reflecting the estimate of β_1^F, the difference between the first two bars of Figure 4(b) shows that for women having experienced a loss in the previous round at the smallest prize of £0.10 instead of winning the same prize of £0.10 induces a reduction in current work effort of 3.4 sliders. The magnitude of this effect is sizeable in the context of a mean level of effort of 25.5 sliders in rounds 3 to 10. In contrast, reflecting that the estimate of β_1^M is close to zero, the negligible difference between the first two bars of Figure 4(a) shows that the current work effort of men does not respond to the outcome of the previous round of competition when the prize in the previous round was minimal. The estimates of β_1^F and β_1^M differ significantly (2-sided $p = 0.061$ in the preferred specification; 2-sided $p = 0.011$ in specification R4 in Appendix A, which additionally controls for the effects of competitive outcomes three rounds previously[10]), which implies a significant difference in how men and women respond to losing independent of the value of the prize that they failed to win.

[10] As discussed in Appendix A, we find no significant effects of competitive outcomes three rounds previously on current behavior, hence specification R4 is not our preferred specification. However, we do find that controlling for competitive outcomes three rounds previously allows us to estimate more precisely the effects of competitive outcomes in the previous period on current work effort.

Our estimate of θ_1^F is close to zero and not significant, indicating that conditional on losing in the previous round a woman's current work effort does not depend on the value of the prize that she failed to win. Graphically, this feature of our results is represented by the approximately equal heights of the two white bars in Figure 4(b), which show women's work effort following a loss at prizes of £0.10 and £3.90 respectively.[11] In contrast, our estimate of θ_1^M is negative and significantly different from zero (2-sided $p = 0.049$), implying that conditional on losing in the previous round a man's work effort decreases in the size of the prize that he failed to win. This behavioral effect is illustrated in Figure 4(a) by the notably lower height of the white bar at a prize of £3.90 as compared to the white bar at a prize of £0.10: after losing at a prize of £3.90 in the previous round, the current work effort of men is 3.2 sliders lower than male work effort after losing at a prize of £0.10. The estimates of θ_1^F and θ_1^M differ significantly (2-sided $p = 0.043$; 2-sided $p = 0.011$ in specification R4 in Appendix A, which additionally controls for the effects of competitive outcomes three rounds previously), which implies a significant difference in how the responses of men and women to losing in the previous round depend on the value of the prize that they failed to win.

The negative estimate of γ_1^F, which is significantly different from zero (2-sided $p = 0.023$), indicates that conditional on winning in the previous round a woman's current work effort decreases in the size of the prize that she won. This is represented graphically in Figure 4(b) by the lower height of the dark bar at a prize of £3.90 as compared to the dark bar at a prize of £0.10: after winning a prize of £3.90 in the previous round, the current work effort of women is about 4.9 sliders lower than after winning a prize of £0.10. For a man, however, conditional on winning in the previous round the value of the prize that he won does not impact on current behavior (γ_1^M is close to zero and insignificant). This is illustrated graphically by the approximately equal heights of the two dark bars in Figure 4(a). The estimates of γ_1^F and γ_1^M differ significantly (2-sided $p = 0.082$; 2-sided $p = 0.081$ in specification R4 in Appendix A, which additionally controls for the effects of competitive outcomes three rounds previously), which implies a significant difference in how the responses of men and women to winning in the previous round depend on the value of the prize that they won.

The above results reveal some striking gender differences in behavioral responses to previous competitive outcomes. In summary, the β_1 and θ_1 estimates together imply that, relative to winning the smallest prize of £0.10, for women losing per se is detrimental to productivity, but for men a loss impacts negatively on productivity only when the prize at stake is big enough. Furthermore the γ_1 estimates imply that, conditional on winning in the previous round, women's current work effort declines in the value of the prize, while there is no such effect for men.

[11] Note that predicted effort provision at intermediate prizes can be obtained via linear interpolation.

Additionally, we note here that a χ^2 test gives $p = 0.052$ for the joint null that β_1, θ_1 and γ_1 do not vary by gender (the corresponding p value based on specification R4 which additionally controls for the effects of competitive outcomes three rounds previously is 0.039).

Table 2 also provides some evidence of the persistence of these effects for women. Losing two rounds previously dampens current effort significantly (negative estimate of β_2^F; 2-sided $p = 0.090$). The effect of the prize conditional on winning also persists for two rounds (negative estimate of γ_2^F; 2-sided $p = 0.031$). In contrast, Table 2 shows that we find no evidence of persistence for men over a two-round horizon. A χ^2 test gives $p = 0.458$ for the joint null that β_2, θ_2 and γ_2 do not vary by gender, and therefore overall we cannot show any significant gender differences in the effects of competitive outcomes two rounds previously on current behavior. Finally, as outlined in Appendix A, we find no evidence that winning or losing has any impact on behavior three rounds later, either for men or for women.

The partial R^2 shows that about 6% of the variation across subjects and rounds observed in the data can be attributed to the winning and losing terms in our model. For women, the partial R^2 suggests that about 11% of the variation can be attributed to the luck terms, while for men about 4% of the variation can be attributed to the response to luck. The Hansen test does not reject the validity of our overidentifying restrictions; therefore we do not reject our additional moments.[12]

In the preferred specification, we use winning and losing as our measure of luck. Arguably, a winner is luckier the more she wins relative to what she expected to win in the round, which in turn depends both on the prize and her probability of winning (from the experimental design, this probability depends linearly on the difference between the winner's effort choice and that of her rival). Similarly a loser is more unlucky the more she expected to win. The second column of Table 2 shows that introducing this more nuanced view of luck does not materially affect our results.[13] The reason is that there is little variation in winning probabilities across winners or across losers, because winning probabilities are mostly condensed in the range $[40\%, 60\%]$. For winners, 79.2% of observations lie in this range across all 10 rounds, while 80.8% do for losers.

4.2.2 Luck and gender differences in efforts

Section 3 described how the whole distribution of work efforts are different by gender, with men exhibiting a higher average level of effort. On average, men completed about 1.8 sliders more than women, and a significantly greater proportion of women's work efforts lie below the sample

[12] In order to test for zero serial correlation in $u_{n,r}$, we run an Arellano-Bond test for the null hypothesis of zero second order autocorrelation in $\Delta u_{n,r}$. This gives p values of 0.202 for the preferred specification and 0.143 for the specification used to check robustness to our measure of luck.

[13] The main difference is that in this alternative specification the evidence for the persistence of the effects for women is weaker.

median. We now use a decomposition analysis to determine the extent to which the differential responses to winning and losing by gender described above can account for this performance gap between men and women.

The decomposition analysis sets the coefficients on the winning and losing terms to zero, while continuing to use the other parameter estimates. To undertake this exercise, we also make the normalizing assumption that winning the smallest prize of £0.10 has the same behavioral impact on men and women, so that none of the gender performance gap after winning the smallest prize is due to a differential response to previous competitive outcomes.[14] Under this assumption, and with the coefficients on the winning and losing terms set to zero, the decomposition analysis predicts that men outperform women by about 0.9 sliders. Thus the differential responses to previous competitive outcomes explain the rest of the performance gap observed in rounds 3 to 10, and so approximately 50% of the performance gap is due to the winning and losing effects.

5 Discussion & conclusion

To the best of our knowledge our paper is the first to study how the productivity of men and women responds to the outcome of previous competitions. Labor markets tend to exhibit repeated competitive interactions: for instance, career opportunities often involve multiple rounds of competition for new positions, promotions, bonuses and pay rises. Our novel findings may help in understanding better some of the sources and dynamics of gender differences in such competitive environments. Alongside more traditional explanations such as discrimination, ability differences and a stronger preference for investing in child-rearing, our findings suggest that the gender gap in labor markets may be driven partly by actual and anticipated responses to the process of winning and losing during competition.

In particular, differential responses by gender to wining and losing account for a significant portion of the gender performance gap that we observe in our experiment: to the extent that these differential responses are also important outside of the experimental laboratory, women in actual labor markets will perform relatively worse as compared to men when forced to compete. Furthermore, if the differential responses to winning and losing that we find are anticipated, women may choose to select into competitive environments at a lower rate than men do. Our results in a dynamic context thus suggest a new mechanism which may help to explain the findings of Niederle and Vesterlund (2007) and others that women shy away from competition even after allowing for differential levels of confidence, risk aversion and aversion to feedback about relative performance. As yet, beyond informal appeals to evolutionary theory, no convincing

[14] We need to make such a normalizing assumption because, as noted in footnote 7, the dummy variables for winning and losing are co-linear, which means that, independent of the prize, we can only distinguish the difference in behavior between having won and lost a previous round.

mechanism or explanation for this residual dislike for competition has been found. As Gneezy et al. (2009) put it: "An important puzzle in this literature relates to the underlying factors responsible for the observed differences in competitive inclinations" (p. 1637).

Further research is required to pin down the processes and mechanisms that might underlie and drive the differential responses by gender to winning and losing that we have identified. Whether these differences are mainly driven by nature or by environmental factors will determine appropriate labor market policy responses. One hypothesis is that winning and losing induce psycho-physiological responses which affect behavior in the next round and which vary by gender. The psycho-physiology literature has identified differences across gender in how mood (Mazur et al., 1997), blood pressure (Holt-Lunstad et al., 2001) and confidence (Roberts, 1991) respond to competitive outcomes. There is evidence that, compared to men, women suffer greater anxiety and elevated cortisol when they compete (Filaire et al., 2009).[15] Buser (2009) and Wozniak et al. (2010) link competition aversion to sex hormones, which also suggests that physiology might be important. On the other hand, Booth and Nolen (2009) and Gneezy et al. (2009) link competition aversion to educational and familial environments, which suggests that factors such as upbringing, culture and institutions could also play a significant role in how men and women react to success and failure in competitive environments.

Further research could also help explain the negative response in work effort after winning a large prize as compared to work effort after winning a small prize that we find for women, which may be related to guilt or egalitarianism. The psychological discomfort associated with guilt may impact directly on performance. Alternatively, if women feel that winning a large prize was undeserved they may wish to reduce effort in the next period to reduce their probability of winning and so redistribute wealth in expectation to other members of the subject pool (see Grund and Sliwka, 2005, and Gill and Stone, 2010, for analyses of how, respectively, inequity and desert concerns affect competitive behavior, and see the survey by Croson and Gneezy, 2009, for evidence that women are more egalitarian than men). Interestingly, Bartling et al. (2009) find that the vast majority of their all-female sample are 'aheadness-averse', that is they are averse to favorable inequity; furthermore, the study finds a significant negative effect of aheadness-aversion on the choice to enter a tournament for women, but no similar effect of aversion to unfavorable inequity.

Finally, we encourage researchers to uncover evidence of how men and women respond to previous competitive outcomes in the field. Our laboratory environment and experimental design allow us sufficient control to identify cleanly responses to winning and losing. Nonetheless, complementary evidence of the importance of the effects that we find from labor markets, ed-

[15] An earlier and longer version of this paper discusses this literature and its relationship to our findings in greater detail (Gill and Prowse, 2010, Section 5.1).

ucational environments and public elections where competition plays a large role and gender differences in outcomes are apparent would be invaluable. Wozniak (forthcoming) provides an interesting first foray in this direction by looking at the degree to which winning is positively correlated over time for both male and female professional tennis players.

Appendix

A Robustness

We examine the robustness of our results by: (i) re-estimating the model using different, more restrictive, instrument sets and (ii) estimating the parameters of a model specification that additionally includes variables describing competitive outcomes three rounds previously.

Results R1, R2 and R3 in Table 3 show that the parameter estimates of the preferred specification in Table 2 are substantively unaffected by various restrictions on the instrument set, which are detailed in the notes to Table 3. The fourth set of results in Table 3, labeled R4, shows that there are no effects on work effort in a given round of competitive outcomes three rounds previously, and that the parameter estimates in Table 2 are not materially affected by the inclusion of the variables detailing these extra competitive outcomes.

B Experimental instructions

Please open the brown envelope you have just collected. I am reading from the four page instructions sheet which you will find in your brown envelope. [**Open brown envelope**]

Thank you for participating in this session. There will be a number of pauses for you to ask questions. During such a pause, please raise your hand if you want to ask a question. Apart from asking questions in this way, you must not communicate with anybody in this room. Please now turn off mobile phones and any other electronic devices. These must remain turned off for the duration of this session. Are there any questions?

You have been allocated to a computer booth according to the number on the card you selected as you came in. You must not look into any of the other computer booths at any time during this session. As you came in you also selected a white sealed envelope. Please now open your white envelope. [**Open white envelope**]

Each white envelope contains a different four digit Participant ID number. To ensure anonymity, your actions in this session are linked to this Participant ID number and at the end of this session you will be paid by Participant ID number. You will be paid a show up fee of £4 together with any money you accumulate during this session. The amount of money you accumulate will depend partly on your actions, partly on the actions of others and partly on chance. All payments will be made in cash in another room. Neither I nor any of the other participants will see how much you have been paid. Please follow the instructions that will appear shortly on your computer screen to enter your four digit Participant ID number. [**Enter four digit Participant ID number**] Please now return your Participant ID number to its

	R1		R2		R3		R4	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
β_1^M (Lost round $r-1$; Men)	-0.180	0.828	-0.023	0.869	0.940	1.087	0.848	0.866
β_2^M (Lost round $r-2$; Men)	-3.206	2.281	-2.910	2.177	-1.779	2.319	-2.464	2.905
β_3^M (Lost round $r-3$; Men)	-	-	-	-	-	-	1.225	0.880
β_1^F (Lost round $r-1$; Women)	-3.417**	1.633	-3.348**	1.626	-3.347**	1.475	-3.847**	1.627
β_2^F (Lost round $r-2$; Women)	-2.209	1.355	-2.126	1.365	-2.196*	1.138	-1.662	1.256
β_3^F (Lost round $r-3$; Women)	-	-	-	-	-	-	0.498	1.584
γ_1^M (Won round $r-1$ × Prize in round $r-1$; Men)	-0.226	0.277	-0.205	0.276	-0.414	0.452	-0.300	0.296
γ_2^M (Won round $r-2$ × Prize in round $r-2$; Men)	-0.821	0.758	-0.774	0.741	-1.028	1.022	-0.847	0.783
γ_3^M (Won round $r-3$ × Prize in round $r-3$; Men)	-	-	-	-	-	-	-0.140	0.317
γ_1^F (Won round $r-1$ × Prize in round $r-1$; Women)	-1.270**	0.583	-1.242**	0.584	-1.085**	0.474	-1.375**	0.541
γ_2^F (Won round $r-2$ × Prize in round $r-2$; Women)	-1.021**	0.506	-1.001**	0.506	-0.808*	0.446	-0.903**	0.451
γ_3^F (Won round $r-3$ × Prize in round $r-3$; Women)	-	-	-	-	-	-	0.201	0.419
θ_1^M (Lost round $r-1$ × Prize in round $r-1$; Men)	-0.876**	0.445	-0.892**	0.453	-1.172*	0.606	-0.973***	0.278
θ_2^M (Lost round $r-2$ × Prize in round $r-2$; Men)	0.053	0.424	0.032	0.426	-0.331	0.622	0.290	0.377
θ_3^M (Lost round $r-3$ × Prize in round $r-3$; Men)	-	-	-	-	-	-	-0.118	0.510
θ_1^F (Lost round $r-1$ × Prize in round $r-1$; Women)	0.166	0.257	0.163	0.256	0.031	0.301	0.133	0.336
θ_2^F (Lost round $r-2$ × Prize in round $r-2$; Women)	0.116	0.504	0.105	0.505	-0.115	0.533	-0.108	0.510
θ_3^F (Lost round $r-3$ × Prize in round $r-3$; Women)	-	-	-	-	-	-	-0.334	0.383
δ_{10}^M (Intercept in round 10; Men)	30.479***	2.216	30.262***	2.177	30.669	3.126	29.414***	1.853
δ_{10}^F (Intercept in round 10; Women)	30.229***	1.978	30.108***	1.958	30.092***	1.882	30.429***	2.047
Hansen test (df, p value)	19.590 (14, 0.144)		18.002 (12, 0.116)		10.348 (8, 0.241)		16.264 (20, 0.700)	
Observations	464		464		464		406	

Notes: For R1 the instrument set is as in the preferred specification, except that the Second Mover's own effort in round $r-2$ is excluded; for R2 all previous values of the Second Mover's own effort are excluded; and for R3 the most recent value of the random draw, the random prize, the interaction of the random draw and the random prize, and the effort of the Second Mover's rival are excluded. Instruments used to obtain results R4 are as in the preferred specification but with one additional lag of each of the instrumental variables. Arellano-Bond tests for the null hypothesis of zero second order autocorrelation in the first differenced transitory errors have p values of 0.204, 0.203, 0.297 and 0.170 for R1-R4 respectively. See also notes 1 and 2 in Table 2.

Table 3: Robustness to choice of instruments and measures of previous competitive outcomes.

envelope, and keep this safe as your Participant ID number will be required for payment at the end.

This session consists of 2 practice rounds, for which you will not be paid, followed by 10 paying rounds with money prizes. In each round you will undertake an identical task lasting 120 seconds. The task will consist of a screen with 48 sliders. Each slider is initially positioned at 0 and can be moved as far as 100. Each slider has a number to its right showing its current position. You can use the mouse in any way you like to move each slider. You can readjust the position of each slider as many times as you wish. Your "points score" in the task will be the number of sliders positioned at exactly 50 at the end of the 120 seconds. Are there any questions?

Before the first practice round, you will discover whether you are a "First Mover" or a "Second Mover". You will remain either a First Mover or a Second Mover for the entirety of this session.

In each round, you will be paired. One pair member will be a First Mover and the other will be a Second Mover. The First Mover will undertake the task first, and then the Second Mover will undertake the task. The Second Mover will see the First Mover's points score before starting the task.

In each paying round, there will be a prize which one pair member will win. Each pair's prize will be chosen randomly at the beginning of the round and will be between £0.10 and £3.90. The winner of the prize will depend on the difference between the First Mover's and the Second Mover's points scores and some element of chance. If the points scores are the same, each pair member will have a 50% chance of winning the prize. If the points scores are not the same, the chance of winning for the pair member with the higher points score increases by 1 percentage point for every increase of 1 in the difference between the points scores, while the chance of winning for the pair member with the lower points score correspondingly decreases by 1 percentage point. The table at the end of these instructions gives the chance of winning for any points score difference. Please look at this table now. [**Look at table**] Are there any questions?

During each task, a number of pieces of information will appear at the top of your screen, including the time remaining, the round number, whether you are a First Mover or a Second Mover, the prize for the round and your points score in the task so far. If you are a Second Mover, you will also see the points score of the First Mover you are paired with.

After both pair members have completed the task, each pair member will see a summary screen showing their own points score, the other pair member's points score, their probability of winning, the prize for the round and whether they were the winner or the loser of the round.

We will now start the first of the two practice rounds. In the practice rounds, you will be paired with an automaton who behaves randomly. Before we start, are there any questions? Please look at your screen now. [**First practice round**] Before we start the second practice round, are there any questions? Please look at your screen now. [**Second practice round**] Are there any questions?

The practice rounds are finished. We will now move on to the 10 paying rounds. In every paying round, each First Mover will be paired with a Second Mover. The pairings will be changed after every round and pairings will not depend on your previous actions. You will not be paired with the same person twice. Furthermore, the pairings are done in such a way that the actions you take in one round cannot affect the actions of the people you will be paired with in later rounds. This also means that the actions of the person you are paired with in a given round cannot be affected by your actions in earlier rounds. (If you are interested, this is because you will not be paired with a person who was paired with someone who had been paired with you, and you will not be paired with a person who was paired with someone who had been paired with someone who had been paired with you, and so on.) Are there any questions?

We will now start the 10 paying rounds. There will be no pauses between the rounds. Before we start the paying rounds, are there any remaining questions? There will be no further opportunities to ask questions. Please look at your screen now. [**10 paying rounds**]

The session is now complete. Your total cash payment, including the show up fee, is displayed on your screen. Please leave the room one by one when asked to do so to receive your payment. Remember to bring the envelope containing your four digit Participant ID number with you but please leave all other materials on your desk. Thank you for participating.

Difference in points scores	Chance of winning prize for Mover with higher score	Chance of winning prize for Mover with lower score
0	50%	50%
1	51%	49%
2	52%	48%
3	53%	47%
4	54%	46%
5	55%	45%
6	56%	44%
7	57%	43%
8	58%	42%
9	59%	41%
10	60%	40%
11	61%	39%
12	62%	38%
13	63%	37%
14	64%	36%
15	65%	35%
16	66%	34%
17	67%	33%
18	68%	32%
19	69%	31%
20	70%	30%
21	71%	29%
22	72%	28%
23	73%	27%
24	74%	26%
25	75%	25%
26	76%	24%
27	77%	23%
28	78%	22%
29	79%	21%
30	80%	20%
31	81%	19%
32	82%	18%
33	83%	17%
34	84%	16%
35	85%	15%
36	86%	14%
37	87%	13%
38	88%	12%
39	89%	11%
40	90%	10%
41	91%	9%
42	92%	8%
43	93%	7%
44	94%	6%
45	95%	5%
46	96%	4%
47	97%	3%
48	98%	2%
49	Not possible as there are only 48 sliders	
50	Not possible as there are only 48 sliders	

Table 4: Chance of winning in a given round.

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