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David Gill  
Victoria Prowse

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**David Gill**

*University of Southampton*

**Victoria Prowse**

*University of Oxford  
and IZA*

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IZA

P.O. Box 7240  
53072 Bonn  
Germany

Phone: +49-228-3894-0  
Fax: +49-228-3894-180  
E-mail: [iza@iza.org](mailto:iza@iza.org)

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## ABSTRACT

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

We present experimental evidence which sheds new light on why women may be less competitive than men. Specifically, we observe striking differences in how men and women respond to good and bad luck in a competitive environment. Following a loss, women tend to reduce effort, and the effect is independent of the monetary value of the prize that the women failed to win. Men, on the other hand, reduce effort only after failing to win large prizes. Responses to previous competitive outcomes explain about 11% of the variation that we observe in women's efforts, but only about 4% of the variation in the effort of men, and differential responses to luck account for about half of the gender performance gap in our experiment. These findings help to explain both female underperformance in environments with repeated competition and the tendency for women to select into tournaments at a lower rate than men.

JEL Classification: C91, D03, J16

Keywords: behavioral preferences, real effort experiment, gender differences, gender gap, competition, competition aversion, tournament, luck, win, loss, narrow framing

Corresponding author:

Victoria Prowse  
University of Oxford  
Department of Economics  
Manor Road Building  
Manor Road  
Oxford, OX1 3UQ  
United Kingdom  
E-mail: [victoria.prowse@economics.ox.ac.uk](mailto:victoria.prowse@economics.ox.ac.uk)

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# 1 Introduction

Are women less competitive than men, and if so why? In this paper we address these questions in a novel light by providing experimental evidence of differences in how men and women respond to experiencing good or bad luck in a competitive work environment. In particular, we find gender differences in how work effort responds to wins and losses in previous rounds of a real effort competition. 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 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 which we control.

Our results show that following a loss, women tend to reduce effort, and the effect is independent of the monetary value of the prize that the women failed to win. Men, on the other hand, reduce effort only after failing to win large prizes. We also find that women lower effort after winning a large prize compared to effort after winning a small prize, but we find no such effect for men. 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 over time for women.

Decomposition analysis shows that these differential responses to luck account for about half of the gender performance gap that we observe in our experiment. Furthermore, our results suggest a new mechanism which may contribute to a greater distaste for competition on the part of women: if the negative response to losing at all prizes and winning at high prizes is mediated by psychological pain or discomfort which is anticipated, women should indeed choose to enter tournaments less frequently than men. The behavioral responses to luck may be mediated by, or correlated with, mood, confidence, stress and blood pressure, and we link our findings to the literature which looks at differences across gender in psycho-physiological responses to winning and losing in competitive environments. Women’s negative response to winning large prizes may also be linked to a higher degree of inequity aversion, which could induce feelings of guilt after winning a large prize or cause women to reduce effort in the following period to reduce their probability of winning and so redistribute wealth in expectation to the other members of the subject pool.

Our findings relate to a growing body of evidence which shows gender differences in competitive environments. In a one-shot competition, Gneezy et al. (2003) show that men perform significantly better at solving mazes, even though there is no significant gender performance gap

when the subjects are paid piece-rate. Similarly, Gneezy and Rustichini (2004) find that boys run faster than girls when competing head-to-head, but not when performing individually, and Ors et al. (2008) find that men perform better in a competitive HEC Paris entrance examination, even though women perform better in high school and in the first year of the course when success is measured against an absolute standard. Using a simple math task, Niederle and Vesterlund (2007) find no gender difference in performance, but do find that women are less likely than men to choose to enter a tournament, even after allowing for differential levels of confidence, risk aversion and aversion to feedback about relative performance. In various settings, Gupta et al. (2005), Garratt et al. (2009), Cason et al. (2010) and Fletschner et al. (2010) also find that women are less likely to choose to compete, while in a repeated environment with a forecasting task Vandegrift and Yavas (2009) find that the selection effect is persistent over time.<sup>1</sup>

Understanding the source of these gender differences in competitive environments is of prime importance for making sense of the gender gap in labor markets and formulating appropriate policy responses. Competition for promotions and bonuses plays an important role in many firms (for evidence from the U.S., Japan and Denmark see Vandegrift and Yavas, 2009, and the references therein). 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.

Standard explanations for the gender gap in labor markets include discrimination, ability differences and a stronger preference for investing in child-rearing. The evidence from Niederle and Vesterlund (2007) and Gneezy et al. (2003) suggests a further explanation: females are more averse to competition and perform worse once forced to compete. Indeed, using Danish survey data, Kleinjans (2009) finds a link between a dislike for competition and occupational choice: women’s stronger distaste for competition appears to decrease expected educational achievement and increase occupational segregation. The contribution of this paper is to suggest a new mechanism which may account for this established greater distaste for competition on the part

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<sup>1</sup>The effect is not universal: for instance Gneezy et al. (2009) find the same effect in a traditional patriarchal society, but not in a matrilineal one; Booth and Nolen (2009) find strong evidence of the effect for girls who attend co-educational schools, but only weak evidence for girls who attend single-sex schools; Dargnies (2009) finds that the gender difference in entry rates into a tournament disappears when subjects compete in teams; while Wozniak et al. (2010) find that, controlling for confidence and risk aversion, feedback about relative performance in an earlier task paid piece-rate eliminates the gender difference in their sample.

of females. As described above, we find differential responses by gender to winning and losing in competitive environments which can explain, at least in part, both female underperformance in environments with repeated competition and the tendency for women to select into tournaments at a lower rate than men. To the extent that women find the experience of losing more painful on average than men do, they may be less inclined to pursue career opportunities which involve multiple rounds of competition for new positions, promotions and pay rises.

If psycho-physiological responses to winning and losing mean that women find competition inherently more unpleasant 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 find competition unpleasant 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 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 distaste 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. Niederle et al. (2010) show that instituting a quota system, whereby at least one of two winners must be female, increases the rate of female entry into a tournament by more than the resulting increase in the probability of winning would predict. Many more high ability women choose to enter so the average quality of the pool of entrants is hardly affected by the quota, suggesting that affirmative action programs may not be very costly. According to the authors, part of the explanation is that the affirmative action reduces the female distaste for competition by making the competition more gender-specific.

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 interprets the results and discusses them in the context of the existing literature; Section 6 concludes; finally, Appendix A offers further robustness analysis while Appendix B lays out the experimental instructions.

## 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). 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).

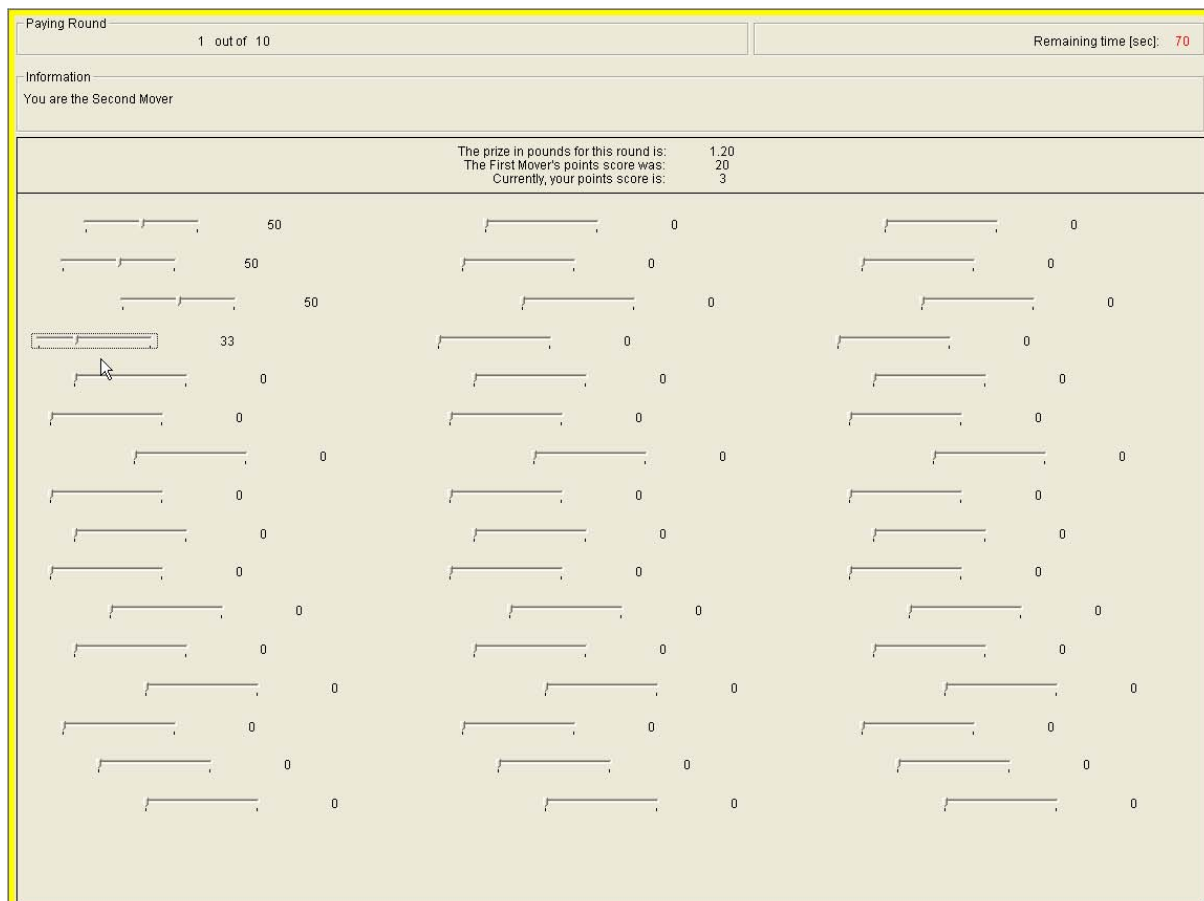
At the start of each session 10 subjects were selected at random and were told that they would be a “First Mover” for the duration of the session. The remaining 10 subjects were told that they would be a “Second Mover” for the entirety of the session. Each session consisted of 2 practice rounds followed 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  $\{\pounds 0.10, \pounds 0.20, \dots, \pounds 3.90\}$  and revealed to the pair members. The First and Second Movers then completed our novel real effort “slider task” sequentially.<sup>2</sup>

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 effort exerted in the task.

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

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<sup>2</sup>In Gill and Prowse (2010), we used the same data set as here to test for disappointment aversion by looking at within-round responses to a rival’s choice of effort.



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.

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.<sup>3</sup> At the end of the session, the final screen asked the subjects to report their gender. There was no mention of gender prior to this final stage, and the experimental instructions distributed at the start of the experiment did not indicate that information on gender would be collected.

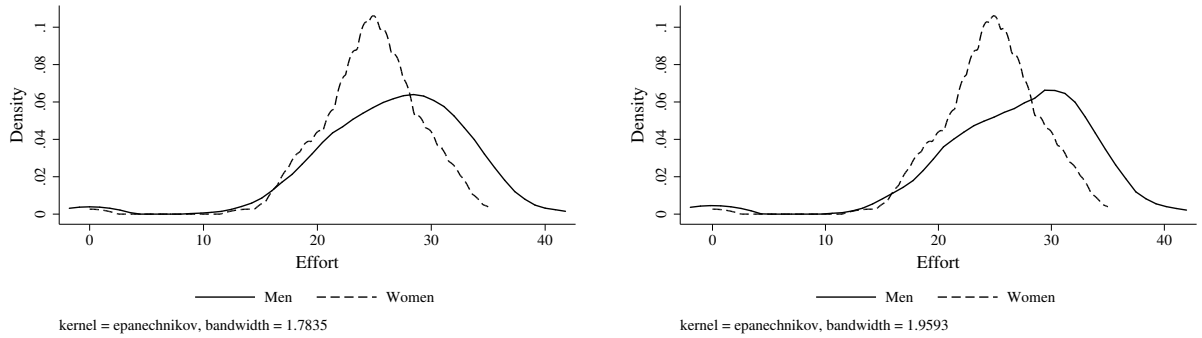
<sup>3</sup>In the practice rounds, the subjects were not told whether they had won or lost.



### 3 Overview of the data

We start by providing an overview of the data. Throughout we analyze only Second Movers:<sup>4</sup> 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 behavior of winning or losing in the two preceding rounds.<sup>5</sup>

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 efforts lie at or below the 60<sup>th</sup> percentile of the effort distribution (the proportion is significantly greater than for men at the 5% level) and 92% lie at or below the 80<sup>th</sup> (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).

<sup>4</sup>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, 2010, 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).

<sup>5</sup>Appendix A shows that there is no effect on behavior in a given round of winning or losing three rounds previously.

	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. Standard errors are bootstrapped allowing clustering at the subject level.

Note 2:  $P(\text{Effort} \leq Q_j)$  denotes the proportion of observations at or below the  $j^{\text{th}}$  percentile of the distribution of effort choices, pooled over men and women. The  $j^{\text{th}}$  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  $P(\text{Effort} \leq Q_j) > j\%$ .

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 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.<sup>6</sup> Significance tests provide support for this gender performance gap: Table 1 reports that the proportion of women's 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 effort split by gender are significantly different from each other (rounds 3 onwards:  $p = 0.007$ ; rounds 6 onwards:  $p = 0.027$ ).<sup>7</sup> 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).

<sup>6</sup>The increase in mean effort from round 1 to round 3 is significantly bigger for women (t test;  $p < 0.05$ ), which suggests that learning is stronger for women in the first few rounds.

<sup>7</sup>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.

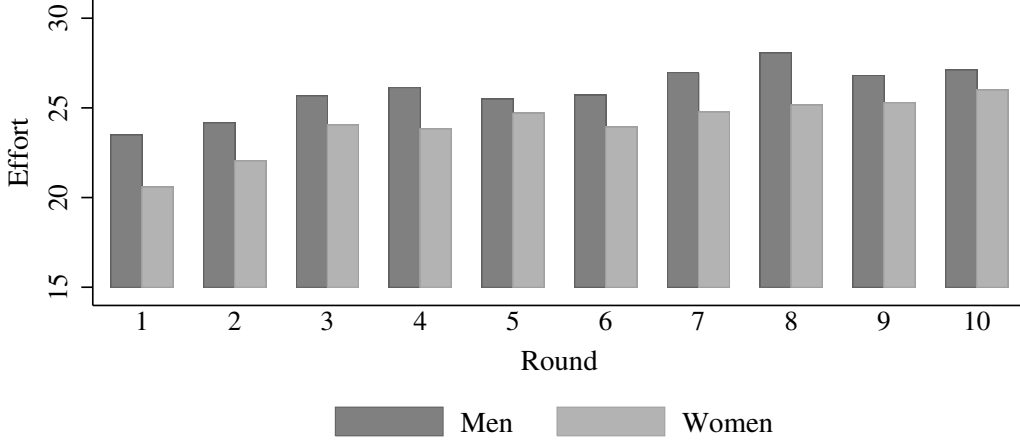


Figure 3: Round by round mean effort choices.

## 4 Empirical analysis

What factors might help to explain the differences in 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.<sup>8</sup> 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 behavior of winning or losing in the two preceding rounds. Specifically, for males, effort in the  $r^{\text{th}}$  round for the  $n^{\text{th}}$  Second Mover,  $e_{n,r}$ , is given by

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

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  $n^{\text{th}}$  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 described above in Section 2, the values of these dummy variables depend partly on the relative

<sup>8</sup>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 4 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.

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  $n^{\text{th}}$  Second Mover was competing for in the  $r^{\text{th}}$  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.<sup>9</sup>

The inclusion of the  $\kappa^M$  and  $\kappa^F$  terms controls for any effect of the current prize on behavior.  $\delta_r^M$  and  $\delta_r^F$  are round specific intercepts, which control for differential learning and average ability by gender.  $\mu_n$  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. Further, all persistence in unobservables is assumed to be captured by the subject-specific fixed effects, and therefore  $u_{n,r}$  is taken to be serially uncorrelated.<sup>10</sup>

The above constitutes a dynamic linear panel data model. By construction, the fixed effect  $\mu_n$  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; Holtz-Eakin et al., 1988). Specifically, taking first differences of (1) gives

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

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).

The design of the experiment provides a number of valid instruments for the variables measur-

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<sup>9</sup> We do not include dummy variables for winning without a prize interaction as the dummy variables for winning and losing are co-linear.

<sup>10</sup>The estimation results support the assumption that  $u_{n,r}$  is serially uncorrelated.

ing the previous competitive outcomes in the first differenced equations: first, we use the random draws which determine whether the  $n^{\text{th}}$  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  $n^{\text{th}}$  Second Mover’s rival in these earlier rounds. Furthermore, we use the  $n^{\text{th}}$  Second Mover’s own effort two and three rounds prior to round  $r$ . All these instruments are also interacted with a dummy variable for the subject being male.<sup>11</sup> Appendix A shows that our results are robust to dropping various subsets of these instruments, and also illustrates that there is a correlation between previous random draws and current effort choices, which provides more direct reduced form evidence that individuals respond to previous competitive outcomes.<sup>12</sup>

## 4.2 Description of results

We start by reporting our parameter estimates. We then translate the estimated parameters into behavioral effects. Finally, we consider whether our results can explain part of the gender difference in 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). We find some striking gender differences in the parameter estimates. The large negative coefficient on  $\beta_1^F$ , which is significantly different from zero at the 5% level, indicates a strong negative impact on effort for women of having lost in the previous round independent of the prize. However, we find no such effect for men. Furthermore, the negative coefficient on  $\gamma_1^F$ , again significant at the 5% level, indicates that when women won a large prize in the previous round they reduce effort compared to when they won a small prize. Again, we find no such effect for men. Instead, men work less hard after having lost when the prize was large compared to having lost when the prize was small (negative coefficient on  $\theta_1^M$ , significant at the 5% level, with no corresponding effect for women). Figure 4 and Table 3, discussed in Section 4.2.2 below, present these results in terms of behavioral impacts.

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<sup>11</sup>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.

<sup>12</sup>As noted in footnote 2, in Gill and Prowse (2010) we analyzed within-round responses to a rival’s choice of effort. Although we found no significant gender differences, we have nonetheless checked that our results here are robust to including First Mover effort and First Mover effort interacted with the prize as explanatory variables.

Table 2 also provides some evidence of the persistence of these effects for women. The impact of losing independent of the prize dampens effort two rounds later (negative coefficient on  $\beta_2^F$ , although the effect is only significant at the 10% level). The negative impact of winning a large prize compared to winning a small prize also persists for two rounds (negative coefficient on  $\gamma_2^F$ , significant at the 5% level). The magnitude of these effects on effort two rounds later are somewhat smaller than for the same effects on effort in the next round. We find no evidence of persistence for men; as outlined in Appendix A, nor do we find evidence that winning or losing has any impact on behavior three rounds later, either for men or for women. Our subjects thus seem to bracket the rounds of the competition fairly narrowly in the sense that they respond temporarily to the outcome of just one or two previous rounds (see Read et al., 1999, for evidence of narrow bracketing more generally).

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 (bootstrapped standard errors show that the partial  $R^2$  is significantly different from zero at the 1% level). For women, the partial  $R^2$  suggests that about 11% of the variation can be attributed to the luck terms (significant at the 5% level), while for men about 4% of the variation can be attributed to the response to luck (significant at the 10% level). The Hansen test does not reject the validity of our overidentifying restrictions; therefore we do not reject our additional moments.<sup>13</sup>

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.<sup>14</sup> 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.

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<sup>13</sup>An Arellano-Bond test for the null hypothesis of zero second order autocorrelation in the first differenced transitory errors has p values of 0.202 for the preferred specification and 0.143 for the specification checking the robustness to our measure of luck. Thus we do not reject our assumption that  $u_{n,r}$  is intertemporally uncorrelated.

<sup>14</sup>The main difference is that in this alternative specification the evidence for the persistence of the effects for women is weaker.

	Preferred		Robustness to	
	Specification		Measure of Luck	
	Estimate	SE	Estimate	SE
$\beta_1^M$ (Lost round $r - 1$ ; Men)	-0.093	0.836	-0.424	0.809
$\beta_2^M$ (Lost round $r - 2$ ; Men)	-3.093	2.213	-2.922	2.262
$\beta_1^F$ (Lost round $r - 1$ ; Women)	-3.499**	1.611	-3.169**	1.613
$\beta_2^F$ (Lost round $r - 2$ ; Women)	-2.271*	1.340	-2.121	1.367
$\gamma_1^M$ (Won round $r - 1 \times$ Prize in round $r - 1$ ; Men)	-0.201	0.273	-0.333	0.529
$\gamma_2^M$ (Won round $r - 2 \times$ Prize in round $r - 2$ ; Men)	-0.773	0.733	-1.584	1.456
$\gamma_1^F$ (Won round $r - 1 \times$ Prize in round $r - 1$ ; Women)	-1.299**	0.570	-2.259**	1.132
$\gamma_2^F$ (Won round $r - 2 \times$ Prize in round $r - 2$ ; Women)	-1.057**	0.491	-1.854*	0.999
$\theta_1^M$ (Lost round $r - 1 \times$ Prize in round $r - 1$ ; Men)	-0.847**	0.431	-1.254**	0.549
$\theta_2^M$ (Lost round $r - 2 \times$ Prize in round $r - 2$ ; Men)	0.071	0.417	-0.025	0.731
$\theta_1^F$ (Lost round $r - 1 \times$ Prize in round $r - 1$ ; Women)	0.168	0.257	0.294	0.501
$\theta_2^F$ (Lost round $r - 2 \times$ Prize in round $r - 2$ ; Women)	0.125	0.502	0.292	0.988
$\delta_{10}^M$ (Intercept in round 10; Men)	30.248***	2.110	30.139***	1.880
$\delta_{10}^F$ (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. Standard errors are robust to heteroskedasticity and allow clustering at the subject level.

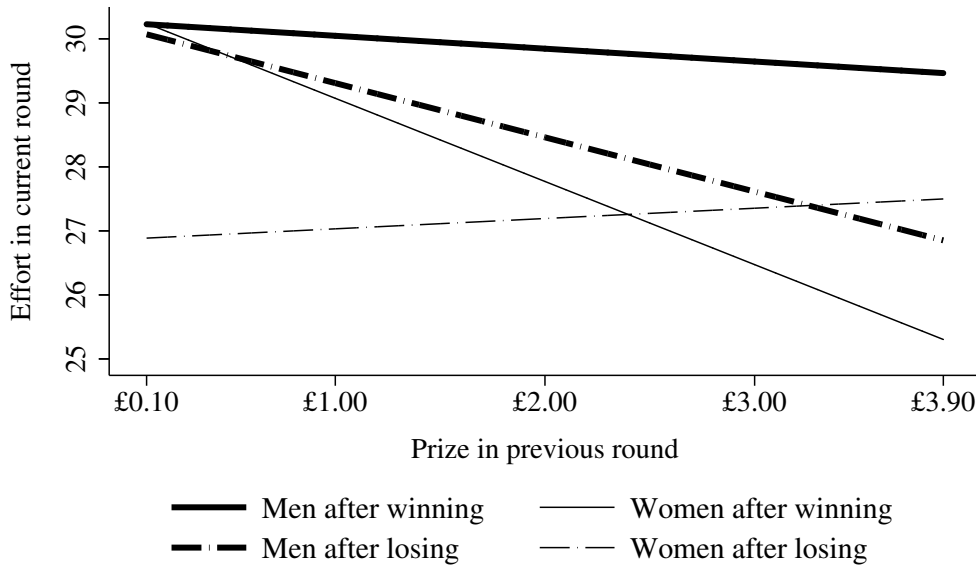
Note 2: The coefficients on the contemporaneous prize effects ( $\kappa^M$  and  $\kappa^F$ ) and on the intercepts ( $\delta_r^M$  and  $\delta_r^F$ ) for rounds 3 to 9 are not reported in the table. The prize effects do not differ significantly by gender.

Note 3: Letting  $P_{n,r-j}$  represent, in proportionate terms, the  $n^{\text{th}}$  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.

### 4.2.2 Behavioral effects

Figure 4 shows how the estimated parameters of the preferred specification from Table 2 translate into behavioral effects. Effort following a win is significantly downward sloping in the prize for women (at the 5% level), and not significantly sloped for men (see the coefficients on  $\gamma_1^F$  and  $\gamma_1^M$  in Table 2). For women, effort following a win at the highest prize of £3.90 is about 4.9 sliders lower than following a win at the lowest prize of £0.10. The reverse holds true for effort following a loss, which is significantly downward sloping in the prize for men (at the 5% level), but not significantly sloped for women (see the coefficients on  $\theta_1^M$  and  $\theta_1^F$ ). For men, effort following a loss at the highest prize of £3.90 is about 3.2 sliders lower than following a loss at the lowest prize of £0.10. These effects are sizeable in the context of a mean level of effort of 25.5 sliders in rounds 3 to 10.



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). Alternative assumptions would shift the lines for men up or down relative to those for women.

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

Table 3 shows, by gender, how winning a given prize impacts on effort relative to losing at the same prize. At low prizes women work significantly less hard following a loss, while there is no significant effect for men: after losing at the lowest prize of £0.10, women reduce effort by about 3.4 sliders compared to having won such a prize; after losing at a prize of £1, women reduce effort by about 2 sliders (both effects are significant at the 5% level). Men, on the other hand, work significantly less hard after losing at larger prizes: after losing at a prize of £2, men reduce effort by about 1.4 sliders compared to having won such a prize; after losing at a prize



of £3 men reduce effort by about 2 sliders; after losing at the highest prize of £3.90 men reduce effort by about 2.6 sliders (the first effect is significant at the 1% level, the other two at the 5% level). There is no similar effect for women: indeed, we find that women actually work *harder* after losing at a large prize than after winning the same prize, though the effect is not significant except at the highest prize of £3.90, and then only marginally so ( $p = 0.093$ ). The magnitude of these effects ranges from about 5% to about 13% of average effort in rounds 3 to 10.

Table 3 also calculates whether these behavioral differences by gender are statistically significant. From the third column we see that, at high prizes, the difference in response by gender to winning relative to losing is strongly significant (at a prize of £3,  $p = 0.013$ ; at a prize of £3.90,  $p = 0.007$ ). At the lowest prize of £0.10, the difference is marginally significant ( $p = 0.067$ ).

Winning relative to losing in previous round at different prizes	Men		Women		Difference	
	Effect	SE	Effect	SE	Effect	SE
£0.10	0.158	0.799	3.352**	1.548	3.195*	1.742
£1.00	0.739	0.529	2.032**	1.007	1.293	1.138
£2.00	1.385***	0.534	0.565	0.612	-0.820	0.812
£3.00	2.031**	0.846	-0.902	0.823	-2.933**	1.180
£3.90	2.612**	1.211	-2.222*	1.325	-4.834***	1.795

Note 1: \*, \*\* and \*\*\* denote, respectively, significance at the 10%, 5% and 1% levels. Standard errors are robust to heteroskedasticity and allow clustering at the subject level.

Note 2: The impact on effort of winning relative to losing at a particular prize is calculated as the difference between effort following a win at that prize and effort following a loss at that prize, as predicted by the estimated parameters of the preferred specification from Table 2.

Table 3: Behavioral impact on efforts from the estimated parameters.

Finally, we calculate how much losing at the highest prize reduces effort in the next round relative to winning the lowest prize. Women reduce effort by about 2.714 sliders (SE=1.306) after losing at a prize of £3.90 compared to winning a prize of £0.10, and the effect is significant at the 5% level. For men, the reduction is slightly bigger at 3.376 sliders (SE=1.418), and is also significant at the 5% level.

In summary, we find that women tend to reduce effort following a loss compared to effort after winning a small prize, and the effect is independent of the monetary value of the prize that the women failed to win. Men, on the other hand, reduce effort only after failing to win large prizes. We also find that women lower effort after winning a large prize compared to winning a small prize, but we find no such effect for men.

### 4.2.3 Luck and gender differences in efforts

Section 3 described how the whole distribution of 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 efforts lie below the sample median. We now use a decomposition analysis to determine the extent to which the differential responses to winning and losing 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 luck.<sup>15</sup> 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 luck 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

Our experiment is designed to test for differences in how men and women respond to winning or losing in a competitive environment. Further research is needed to establish exactly what drives the differences we have discovered. However, we can formulate some hypotheses about the processes which might underlie our subjects' behavior. One hypothesis is that winning and losing induce emotional or other psycho-physiological responses which affect behavior in the next round, and that the strength and nature of these responses vary by gender. In this light, a plausible interpretation of the effects presented in Figure 4 is that women find losing painful or unpleasant, whatever the level of the prize, while men only dislike losing when the prize is substantial, and that women also dislike winning large prizes. As a result, women may have a stronger aversion to competition than men do.

Below, we start by referring to some existing evidence regarding the emotional or other psycho-physiological processes which might underlie the different responses to winning and losing by gender. We then link our discussion to the existing economics literature on gender differences in competition, which has found that women underperform in competitive environments and choose to enter tournaments at a lower rate than men.

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<sup>15</sup>We need to make such a normalizing assumption because, as noted in footnote 9, 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.

## 5.1 Emotional and other psycho-physiological responses

Some of the behavioral responses outlined above may be mediated by, or correlated with, mood, confidence, stress, blood pressure and testosterone. The psychology and physiology literatures have studied differences across gender in psycho-physiological responses to winning and losing in competitive environments. For example, there is some evidence of gender differences in how blood pressure and mood respond to winning and losing. Using a categorization-based task with a \$5 prize for the winner, Holt-Lunstad et al. (2001) find a differential response in diastolic blood pressure: male winners' blood pressure is lower for than for losers, while the result is reversed for females. The authors interpret this as evidence that women fear success, while there is a norm of success for men. Mazur et al. (1997) find evidence that, in the absence of any monetary incentive, women's mood responds negatively to losing a computer game, while the mood of men does not. Following a win, however, women's and men's moods are essentially the same. These different responses in mood may also be linked to self-confidence: Roberts (1991) surveys the evidence which shows that women's confidence about their own ability is more sensitive to failure than men's, while men tend to attribute failure more to bad luck.

There is also evidence that women suffer greater stress in competitive environments. Mazur et al. (1997) argue that elevated cortisol levels in their female subjects suggests that they found the competitive environment more stressful than men (despite the lack of monetary incentives). This chimes with Holt-Lunstad et al. (2001), who find that self-reported levels of stress are higher for women throughout their competition. Filaire et al. (2009) find that women exhibit higher anxiety and higher cortisol levels than men during the first round of a tennis tournament (even though pre-match day cortisol levels did not vary by gender). Erickson et al. (2003) and Dickerson and Kemeny (2004) review the substantial literature linking psychological anxiety and stress to elevated levels of cortisol.

Testosterone is linked to dominant and aggressive behavior and is found in much higher levels in men (Mazur and Booth, 1998). The physiology literature has found that the testosterone level of male winners tends to be higher than that of male losers (e.g., Elias, 1981, for wrestlers, Booth et al., 1989, for tennis players, and Gladue et al., 1989, in the context of a reaction time task). Archer (2006) confirms the significance of the finding from a statistical meta-analysis of the data, while the survey by Mazur and Booth (1998) reports that the rise in testosterone after a win is associated with a subject's elated mood. Furthermore, there is some evidence that the response is mediated by the importance of the competition: Mazur et al. (1992) find that for male chess players the differential response is stronger when more is at stake and when the players are closely matched, thus providing evidence "that contestants must take their competition seriously if it is

to affect their T levels” (p. 75). For women, on the other hand, most of the evidence shows no difference in testosterone levels. According to Kivlighan et al. (2005), differential testosterone responses to winning and losing have never been observed in women, although a contrary result was found recently by Oliveira et al. (2009) in the context of female soccer players.

Finally, women’s negative response to winning large prizes may be related to feelings of guilt or a concern for egalitarianism. Two possible mechanisms suggest themselves. 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). A number of studies provide evidence from dictator games that women are more inequity averse or egalitarian than men (e.g., Eckel and Grossman, 1998, and Andreoni and Vesterlund, 2001; see Croson and Gneezy, 2009, for a survey of the evidence). 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 (‘behindness-aversion’).

## 5.2 Female competition aversion

As outlined in the Introduction, a recent but growing literature indicates that women are less competitive than men: women perform less well relative to men when they compete compared to when performance is measured in absolute terms (e.g., Gneezy et al., 2003, Gneezy and Rustichini, 2004, Ors et al., 2008); furthermore, women choose to compete less frequently than men (e.g., Gupta et al., 2005, Vandegrift and Yavas, 2009, Fletschner et al., 2010). Niederle and Vesterlund (2007) find that women shy away from competition even when they are as able as men, and provide evidence that men have a stronger preference for performing in a competitive environment 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 mechanism or explanation for this residual distaste for competition exists. Booth and Nolen (2009)’s and Gneezy et al. (2009)’s results suggest that culture and upbringing may have some influence, while those of Buser (2009) and Wozniak et al. (2010) indicate that female sex hormones play a mediating role. 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).

One contribution of our research is to suggest a new mechanism which may account, at least in part, for this aversion to competition on the part of females. If women’s negative response to losing at all prizes and winning at high prizes is mediated by psychological pain or discomfort, and women anticipate these psychological effects when deciding whether or not to compete, women should indeed choose to enter tournaments less frequently than men, who respond only to losing at high prizes. Of course, this line of argument assumes that the relationship between psychological effects and behavioral impacts is of the same magnitude for men and women. Furthermore, as explained in Section 4.2.3, differential responses to winning and losing can account for about half of the gender performance gap in our experiment. Thus, any underperformance of women when they do choose to compete may also derive in part from the differential responses to luck across gender.<sup>16</sup>

Risk aversion, in the standard sense of concave utility over money, cannot explain the negative responses to losing that we observe, as marginal utility is higher after losing than after winning so the incentive to exert effort should be stronger.<sup>17</sup> Thus, researchers should be wary of interpreting a refusal to compete as a refusal to accept the implicit monetary gamble involved in the competition. In particular, our results suggest that women are much more likely than men to refuse to compete when the stakes are low. If this were interpreted as evidence for risk aversion, the estimated curvature of money utility would be very large indeed for women. Niederle and Vesterlund (2007, p. 1084) note that the degree of risk aversion needed to explain the low rate of entry into their tournament of the high-ability women in their sample is implausibly high. Of course, risk aversion may nonetheless play *some* role in women’s decision to enter tournaments at a lower rate than men. Gupta et al. (2005), Booth and Nolen (2009) and Fletschner et al. (2010) find that differential risk aversion across gender (as measured by responses to hypothetical scenarios) explains a portion of the gender gap in selection into tournaments, while Bartling et al. (2009) and Buser (2009) find that more risk averse females choose to compete significantly less frequently than those that are less risk averse.

## 6 Conclusion

A growing body of literature documents the inferior performance of women in competitive environments and the tendency for women to choose to enter competitions less frequently than men (e.g., Gneezy et al., 2003, Niederle and Vesterlund, 2007). In this paper we have provided evidence which sheds new light on why women may be less competitive than men. Specifically,

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<sup>16</sup>Our results explain female underperformance in one-shot experiments only if women are responding to previous wins and losses that occurred outside the laboratory.

<sup>17</sup>It is possible that strongly concave utility can explain some of the women’s reduction in effort after winning high prizes, though it is not clear why the effect should be temporary.

we have documented large and significant gender differences in behavioral responses to the outcomes of previous competitive interactions. Women's performance declines following a loss at any prize value, while men respond negatively only when they lose a large prize. Furthermore, women respond negatively to winning large prizes but no such effect exists for men. Overall, these behavioral responses to the outcomes of previous competition explain 11% of the observed variation in women's effort but only 4% of the observed variation in the effort of men. Thus, in addition to finding different behavioral effects of winning and losing for men and women, we conclude that previous competitive outcomes constitute a larger determinant of effort choices for women than for men.

The gender pay gap is a well documented phenomenon (e.g., Altonji and Blank, 1999, Bertrand and Hallock, 2001), existing in numerous countries and affecting women across the spectrum of educational qualifications. Previous authors have noted that the occupational segregation and flatter career paths of women may be linked to female aversion to competition (in particular, see Kleinjans, 2009). Our results provide a possible explanation for female aversion to competition and for gender differences in labor market outcomes. Specifically, professional success and progression requires repeated competitive interactions in the form of multiple rounds of job applications and frequent assessments for internal promotions. To the extent that women find the experience of losing more painful on average than men do, they may be less inclined to pursue such opportunities.

Our findings leave open a number of interesting avenues for further research. First, it would be interesting to pin down the mechanisms which underlie the different behavioral responses that we have identified. Are they driven by psycho-physiological processes such as changes in mood, hormones or testosterone? The discussion in Section 5.1 and the findings of Buser (2009) and Wozniak et al. (2010), which link competition aversion to sex hormones, suggest that such psycho-physiological processes may indeed play an important role. Can the different responses by gender be molded by culture and upbringing? The recent papers by Booth and Nolen (2009) and Gneezy et al. (2009), which link female competition aversion to nurture, suggest that culture and upbringing could also play a significant role in how men and women react to failure and success. Finally, it would be important to extend our results to field evidence from labor markets, educational environments and public elections where competition plays a large role and gender differences in outcomes are apparent.

# Appendix

## A Robustness

We examine the robustness of our results by: (i) re-estimating the model using different, more restrictive, instrument sets; (ii) estimating the parameters of a model specification that additionally includes variables describing competitive outcomes three rounds previously; and (iii) examining whether the data show any direct effects on current behavior of the previous values of the exogenous random draws which, as explained in Section 2, determine the winner of the prize for each pair in every round.

Results R1, R2 and R3 in Table 4 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 4. The fourth set of results in Table 4, 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.

Our final robustness check analyzes the direct effects on Second Movers' efforts in a given round of the random draws which determined whether they won or lost in previous rounds. By construction these random draws are exogenous and positively correlated with winning for Second Movers; thus, by looking directly at the relationship between the previous random draws and current work effort, we sidestep the endogeneity problem arising from the persistence of unobservables which required us to use instrumental variables.

S1 in Table 5 shows the results of a linear random effects panel data regression of Second Mover effort in a given round on the values of the random draw for that Second Mover in the three previous rounds. The random draw in the previous round has a positive effect (significant at the 5% level) on the work effort of women. For men the effect is also positive but of smaller magnitude, and is only significant at the 10% level. Specification S2 additionally includes the random draws interacted with the corresponding prize value. The effects for both men and women become stronger and more significant. For women, we also see a significant negative effect of the interaction term and persistence of the effects for two rounds. This reduced-form evidence confirms that our subjects respond to previous competitive outcomes, that the impacts are more persistent for women, and that neither men nor women respond to competitive outcomes that occurred three rounds previously.

	R1		R2		R3		R4	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
$\beta_1^M$ (Lost round $r - 1$ ; Men)	-0.180	0.828	-0.023	0.869	0.940	1.087	0.848	0.866
$\beta_2^M$ (Lost round $r - 2$ ; Men)	-3.206	2.281	-2.910	2.177	-1.779	2.319	-2.464	2.905
$\beta_3^M$ (Lost round $r - 3$ ; Men)	-	-	-	-	-	-	1.225	0.880
$\beta_1^F$ (Lost round $r - 1$ ; Women)	-3.417**	1.633	-3.348**	1.626	-3.347**	1.475	-3.847**	1.627
$\beta_2^F$ (Lost round $r - 2$ ; Women)	-2.209	1.355	-2.126	1.365	-2.196*	1.138	-1.662	1.256
$\beta_3^F$ (Lost round $r - 3$ ; Women)	-	-	-	-	-	-	0.498	1.584
$\gamma_1^M$ (Won round $r - 1 \times$ Prize in round $r - 1$ ; Men)	-0.226	0.277	-0.205	0.276	-0.414	0.452	-0.300	0.296
$\gamma_2^M$ (Won round $r - 2 \times$ Prize in round $r - 2$ ; Men)	-0.821	0.758	-0.774	0.741	-1.028	1.022	-0.847	0.783
$\gamma_3^M$ (Won round $r - 3 \times$ Prize in round $r - 3$ ; Men)	-	-	-	-	-	-	-0.140	0.317
$\gamma_1^F$ (Won round $r - 1 \times$ Prize in round $r - 1$ ; Women)	-1.270**	0.583	-1.242**	0.584	-1.085**	0.474	-1.375**	0.541
$\gamma_2^F$ (Won round $r - 2 \times$ Prize in round $r - 2$ ; Women)	-1.021**	0.506	-1.001**	0.506	-0.808*	0.446	-0.903**	0.451
$\gamma_3^F$ (Won round $r - 3 \times$ Prize in round $r - 3$ ; Women)	-	-	-	-	-	-	0.201	0.419
$\theta_1^M$ (Lost round $r - 1 \times$ Prize in round $r - 1$ ; Men)	-0.876**	0.445	-0.892**	0.453	-1.172*	0.606	-0.973***	0.278
$\theta_2^M$ (Lost round $r - 2 \times$ Prize in round $r - 2$ ; Men)	0.053	0.424	0.032	0.426	-0.331	0.622	0.290	0.377
$\theta_3^M$ (Lost round $r - 3 \times$ Prize in round $r - 3$ ; Men)	-	-	-	-	-	-	-0.118	0.510
$\theta_1^F$ (Lost round $r - 1 \times$ Prize in round $r - 1$ ; Women)	0.166	0.257	0.163	0.256	0.031	0.301	0.133	0.336
$\theta_2^F$ (Lost round $r - 2 \times$ Prize in round $r - 2$ ; Women)	0.116	0.504	0.105	0.505	-0.115	0.533	-0.108	0.510
$\theta_3^F$ (Lost round $r - 3 \times$ Prize in round $r - 3$ ; Women)	-	-	-	-	-	-	-0.334	0.383
$\delta_{10}^M$ (Intercept in round 10; Men)	30.479***	2.216	30.262***	2.177	30.669	3.126	29.414***	1.853
$\delta_{10}^F$ (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 4: Robustness to choice of instruments and measures of previous competitive outcomes.



	S1		S2	
	Estimate	SE	Estimate	SE
Random draw in round $r - 1$ ; Men	0.864*	0.510	1.443**	0.686
Random draw in round $r - 2$ ; Men	-0.073	0.976	1.197	2.325
Random draw in round $r - 3$ ; Men	-2.312	1.539	-2.122	2.013
Random draw in round $r - 1$ ; Women	1.443**	0.669	3.396***	0.973
Random draw in round $r - 2$ ; Women	-0.141	0.950	1.793**	0.781
Random draw in round $r - 3$ ; Women	0.145	0.822	0.276	1.307
Random draw in round $r - 1 \times$ Prize in round $r - 1$ ; Men	-	-	-0.297	0.294
Random draw in round $r - 2 \times$ Prize in round $r - 2$ ; Men	-	-	-0.627	0.732
Random draw in round $r - 3 \times$ Prize in round $r - 3$ ; Men	-	-	-0.179	0.339
Random draw in round $r - 1 \times$ Prize in round $r - 1$ ; Women	-	-	-1.041***	0.381
Random draw in round $r - 2 \times$ Prize in round $r - 2$ ; Women	-	-	-1.090**	0.424
Random draw in round $r - 3 \times$ Prize in round $r - 3$ ; Women	-	-	0.006	0.420
Intercept; Men	27.250***	1.593	27.406***	1.324
Intercept; Women	23.880***	1.284	23.908***	0.886
Observations	406		406	

Notes: \*,\*\* and \*\*\* denote, respectively, significance at the 10%, 5% and 1% levels. Standard errors are robust to heteroskedasticity and allow clustering at the subject level.

Table 5: Direct effect of previous random draws on current effort.

## 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 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 6: Chance of winning in a given round.

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