

# Gender differences and dynamics in competition: The role of luck

DAVID GILL

Department of Economics, Oxford University

VICTORIA PROWSE

Department of Economics, Cornell University

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, luck, productivity, relative performance evaluation, tournament, winning, losing.

**JEL CLASSIFICATION.** C91, D03, J16.

## 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 involve 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

---

David Gill: [d.gill@univ.oxon.org](mailto:d.gill@univ.oxon.org)

Victoria Prowse: [prowse@cornell.edu](mailto:prowse@cornell.edu)

Financial support from the George Webb Medley Fund and a Southampton School of Social Sciences Small Grant is gratefully acknowledged. We also thank the Nuffield Centre for Experimental Social Sciences for hosting our experiments. Finally, we thank the editor and three anonymous referees for their helpful comments.

Copyright © 2014 David Gill and Victoria Prowse. Licensed under the [Creative Commons Attribution-NonCommercial License 3.0](https://creativecommons.org/licenses/by-nc/3.0/). Available at <http://www.qeconomics.org>.

DOI: [10.3982/QE309](https://doi.org/10.3982/QE309)

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.<sup>1</sup> In each of 10 rounds, subjects are paired and informed of the value of the monetary prize for which they are competing, 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 that 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 data set that is detailed enough to estimate accurately the impact in a given round of winning and losing in previous rounds by gender.

The data set that we analyze here is the same as used in [Gill and Prowse \(2012\)](#). Gender differences had no bearing on the results of that paper ([Gill and Prowse \(2009, p. 15\)](#)), in which we tested for the presence of a specific form of reference-dependent preferences by looking at within-round responses to a rival’s choice of effort; dynamic behavior over time played no role at all. Here, we look at the dynamics of how the subjects respond to winning and losing across rounds. To make sure that the results here are not contaminated by the within-round effect studied by [Gill and Prowse \(2012\)](#) whereby the effort of second movers falls in that of their first mover rival, we show in the [Appendix](#) that the results in this paper are robust to including contemporaneous first mover effort and first mover effort interacted with the prize as explanatory variables.

In our empirical analysis, we explore how effort provision responds to the outcomes of previous rounds of competitive interaction, that is, previous wins and losses. We use fixed effects dynamic panel data methods and control for permanent individual-level ability, time effects, and prize effects. Similarly to [Ham, Kagel, and Lehrer \(2005\)](#) and

---

<sup>1</sup>Using data from men’s and women’s professional tennis, [Wozniak \(2012\)](#) looked at the impact of wins on players’ decisions to enter later tournaments and at the degree to which wins are positively correlated. We are also aware of two papers that look at how gender affects the relationship between risk taking and previous monetary gains or losses. [Cummins, Nadorff, and Kelly \(2009\)](#) found no effect of gender, and [Lam and Ozorio \(2013\)](#) found the same for subjects with no experience of casino gambling. For subjects with experience of casino gambling, [Lam and Ozorio \(2013\)](#) found that men take more risk after a monetary gain than a loss, but the reverse holds true for women. These two papers build on [Thaler and Johnson \(1990\)](#), who did not study the effect of gender, but found risk seeking after a monetary gain, risk aversion after a monetary loss, and a “break even effect” whereby bets that offer the opportunity to break even are particularly attractive.

Costa-Gomes, Huck, and Weizsäcker (2012), we exploit randomization induced by the experimental design to obtain a number of valid instruments for the variables that measure previous competitive outcomes. We note that the randomness present in the experimental design is critical to our identification strategy: it is this randomness that allows us to estimate the causal effect of previous competitive outcomes on current effort provision.<sup>2</sup> After controlling for permanent individual ability, previous competitive outcomes are largely determined by chance, and therefore we interpret the response to previous competitive outcomes as a response to luck. We show that our results are robust to our measure of luck. Specifically, we look also at the response of effort to a purer measure 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) and Bertrand (2011) surveyed the large literature on the impact of gender on labor market outcomes; Altonji and Blank (1999, p. 3249) concluded that “a large share of gender differentials remain ‘unexplained’ even after controlling for detailed measures of individual and job characteristics.” Eckel (2008) surveyed the existing evidence from laboratory experiments on gender differences that might help to shed light on the gender gap. The gender gap is particularly stark at the top of the corporate hierarchy:

---

<sup>2</sup>Fundamentally, any persistent unobserved variables that affect work effort, such as ability, will be correlated with the measure of previous competitive success. This endogeneity issue is thus a feature of the problem we are analyzing rather than the result of poor experimental design. Nonetheless, our design is well suited to identifying the causal effect of previous competitive outcomes on work effort. Crucially, conditional on the efforts of the pair members, prizes were awarded randomly. This randomness provides us with instruments, valid by construction, that allow us to identify the causal effect of previous competitive outcomes on current effort. Thus, our identification strategy does not rely on untestable assumptions about stochastic unobservables. The endogeneity issue introduced by the dynamic nature of the problem means that traditional control/treatment designs are not appropriate in this case. Indeed, the experimental literature has started to consider the use of instruments in the presence of unavoidable endogeneity (notably, see Costa-Gomes, Huck, and Weizsäcker (2012, pp. 19–20)).

Bertrand and Hallock (2001) found that only 2.5% of top U.S. executives are female and that these female executives earn 45% less than their male counterparts; using a longer data set with a more recent end year, Wolfers (2006) and Bertrand (2009) noted that only 1.3% of chief executive officers are female. Arguably, competition for these top jobs is more intense than for lower or middle-ranking positions that 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 winning 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 that 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 that 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)).<sup>3</sup> Using Danish survey data, Kleinjans (2009) found 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 relative performance of women tends to deteriorate when they are forced to compete (e.g., Gneezy, Niederle, and Rustichini (2003), Gneezy and Rustichini (2004), and Ors, Palomino, and Peyrache (forthcoming); Iriberry and Rey-Biel (2012) found that information about competitor genders matters).

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

---

<sup>3</sup>For further supporting evidence, see, for instance, Gupta, Poulsen, and Villeval (2005), Garratt, Weinberger, and Johnson (2013), Vandegrift and Yavas (2009), Cason, Masters, and Sheremeta (2010), and Fletschner, Anderson, and Cullen (2010). However, Gneezy, Leonard, and List (2009) found the same effect in a traditional patriarchal society, but not in a matrilineal one, Charness and Villeval (2009) found no effect, Kamas and Preston (2012) found differences only for business majors, Wozniak, Harbaugh, and Mayr (2010) found that feedback about relative performance in a piece-rate stage reduces the gender entry gap, and Charness, Rustichini, and van de Ven (2012) found no effect when controlling for confidence.

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 so as 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 the 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, affirmative action may reduce efficiency but will improve equity across gender in society. Surprisingly, efficiency might not be impaired: [Niederle, Segal, and Vesterlund \(2013\)](#) found 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, and the [Appendix](#) offers further robustness analysis.

## 2. EXPERIMENTAL DESIGN

We ran six 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. Twenty 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; [Greiner \(2004\)](#)). Gender played no role in the subject recruitment and 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 were provided to each subject in written form and were read aloud to the subjects (the instructions can be found in [Gill and Prowse \(2010\)](#), an earlier version of this paper). 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 paired again after every round using [Cooper et al.’s \(1996\)](#) 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 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 (we call the points score “effort” or the “effort choice”). As the slider task gives a finely gradated measure of performance over a short time scale, we can construct a panel data set that is detailed enough to allow robust statistical inference.<sup>4</sup> As discussed in the [Introduction](#), Gill and Prowse

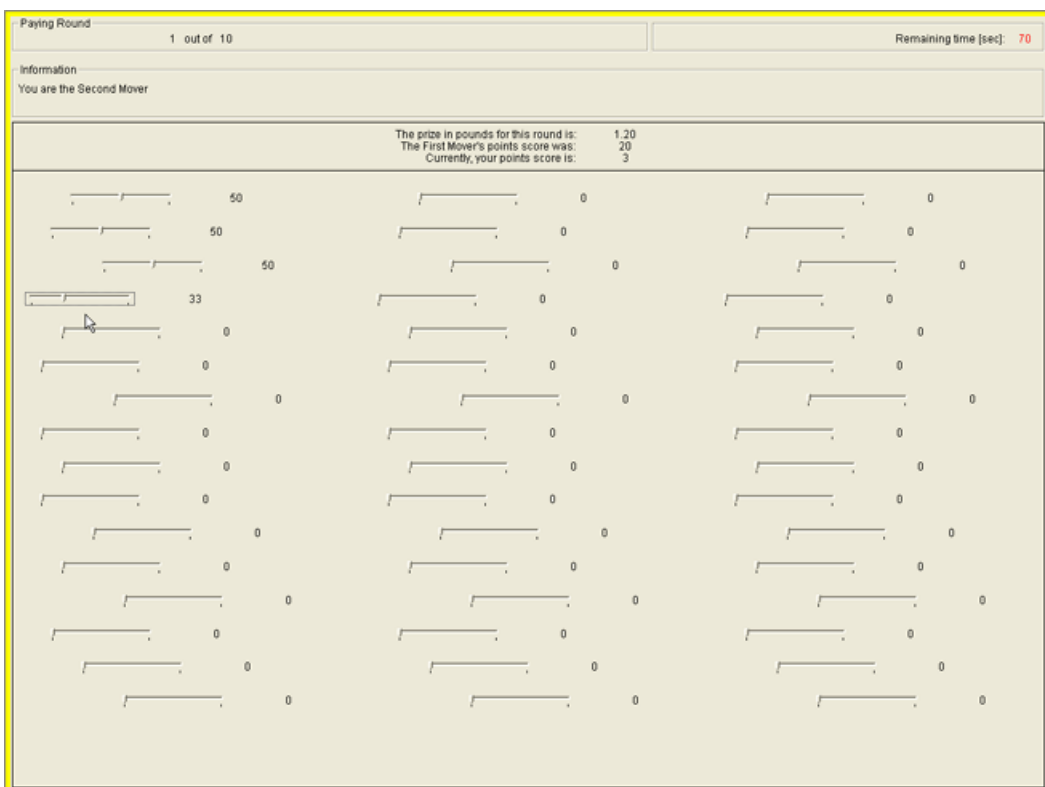


FIGURE 1. Screen showing 48 sliders. *Notes:* The sliders were displayed on 22 inch wide screen monitors with a 1680 by 1050 pixel resolution. To move the sliders, the subjects used 800 dpi USB mice with the scroll wheel disabled. To ensure that all the sliders are equally difficult to position correctly, the 48 sliders are arranged on the screen such that no two sliders are aligned exactly one under the other.

<sup>4</sup>Gill and Prowse (2011) provided details of how to implement the task, which was first used in Gill and Prowse (2012), and has since been used by Hetzel (2010), Bonein and Denant-Boemont (2011),

(2012) used the same data set as here. See [Charness and Kuhn \(2010\)](#) for a discussion of the advantages and disadvantages of using real effort in labor market experiments.

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 with whom he or she was paired 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, a reminder of 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>5</sup> Section IV of [Gill and Prowse \(2012\)](#) describes an incentivized comprehension quiz using a different sample of subjects that provides evidence that subjects understood the experimental instructions well.

### 3. OVERVIEW OF THE DATA

We start by providing an overview of the data. Throughout we analyze only second movers:<sup>6</sup> our sample consists of 30 male second movers and 28 female second movers

---

[Cettolin and Riedl \(2011\)](#), [Eacret, Lafferty, and Jhunjhunwala \(2011\)](#), [Hammermann, Mohnen, and Nieken \(2011\)](#), [Riener and Wiederhold \(2011\)](#), [Djawadi and Fahr \(2012\)](#), [Gill, Prowse, and Vlassopoulos \(2013\)](#), [Kimbrough and Reiss \(2012\)](#), and [Monahan \(2012\)](#).

<sup>5</sup>In the practice rounds, the subjects were not told whether they had won or lost.

<sup>6</sup>The first movers face a different situation to that of the second movers on a number of dimensions that could influence or moderate the impact of previous wins and losses. The [Appendix](#) shows that for female first movers there is only a marginally significant effect on current work effort of last period's competitive outcome, while for men there is no effect at all. Most importantly, 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 \(2012\)](#) showed that the second movers do indeed respond to first mover effort choices). The process of thinking about how to influence the rival's choice in the current round may influence how subjects respond to previous wins and losses. A second important difference is that 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 in the previous round before starting the task (while they wait for 2 minutes for the new first mover they have been paired with to complete the task). The idea that subjects need some time to internalize any psychological effects from winning or losing is consistent with the hypothesis discussed in [Section 5](#) that the effects of winning and losing are mediated by psychophysiological responses. It is standard practice in the psychophysiological literature to wait some time before collecting samples for hormonal assay or measuring mood. For instance, in [Mazur, Susman, and Edelbrock's \(1997\)](#) study of male and female responses

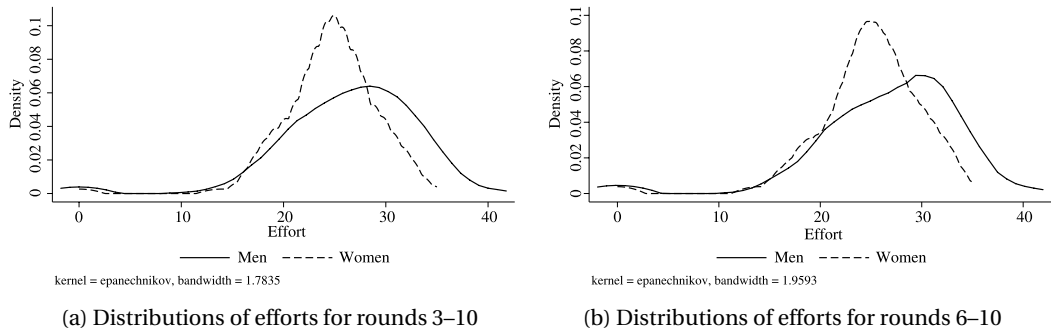


FIGURE 2. Distributions of effort choices.

observed completing the slider task in each of the 10 paying rounds (2 second movers did not report their gender). The analysis focuses on behavior in rounds 3 onward to allow for the effect on productivity of winning or losing in the two preceding rounds. The [Appendix](#) 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 (the [Appendix](#) provides further summary statistics split by gender, the competitive outcome in the previous round, and the prize in the previous round). 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.

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 60th percentile of the effort distribution (the proportion is significantly greater than for men at the 5% level) and 92% lie at or below the 80th percentile (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\(b\)](#).

The tendency for women not to exert high levels of effort is such 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.<sup>7</sup> 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

to winning and losing a computer game, subjects waited 2 minutes after the end of the competition before providing saliva and then reporting their mood. Finally, second movers directly control their probability of winning during the task (as they know the effort of the first mover with whom they have been paired), while first movers only find out what their probability of winning was at the same time that they discover whether they won or lost the round. Responses to previous wins and losses may well depend on the degree of control subjects are able to exert on the chances of wins and losses occurring (both in the current round and in previous rounds).

<sup>7</sup>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.



TABLE 1. Descriptive analysis of effort choices of men and women.

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

Notes: 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.

2. P(Effort ≤ Q<sub>j</sub>) denotes the proportion of observations at or below the jth percentile of the distribution of effort choices, pooled over men and women. The jth 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 ≤ Q<sub>j</sub>) > j%. For example, for the case P(Effort ≤ Q<sub>20</sub>) both proportions exceed 0.2.

at the 5% level (for rounds 3 onward and for rounds 6 onward); 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 onward,  $p = 0.007$ ; rounds 6 onward,  $p = 0.027$ ),<sup>8</sup> and a rank sum test shows that the distributions are marginally significantly different from each other (rounds 3 onward,  $p = 0.066$ ).<sup>9</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).

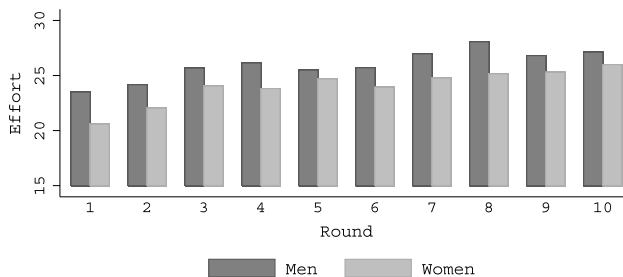


FIGURE 3. Round-by-round mean effort choices.

<sup>8</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.

<sup>9</sup>Since the rank sum test requires independent observations, we use each subject’s average effort from round 3 onward.

## 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.<sup>10</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 onward to allow for the effect on productivity of winning or losing in the two preceding rounds. Our econometric strategy additionally accounts for permanent individual-level ability differences, time effects, and prize effects. Specifically, for males, work effort in the  $r$ th round for the  $n$ th second mover,  $e_{n,r}$ , is given by

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

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

In (1),  $L_{n,r-1}$  is a dummy variable that takes a value of 1 if the  $n$ th second mover lost in the previous round and zero otherwise. The notation  $W_{n,r-1}$  is the equivalent dummy variable in the case of a win. Expressions  $L_{n,r-2}$  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 work effort of the pair members and partly on luck, in the form of the random draw.

The variable  $v_{n,r}$  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.<sup>11</sup>

<sup>10</sup>As we see in Table 2, measuring luck in terms of monetary winnings relative to what was expected does not materially affect our results. Footnote 6 explains why we focus on second movers. As outlined in the Appendix, we found no evidence that behavior in a given round was affected by winning or losing three rounds previously. The Appendix also shows that our estimates of the preferred specification are largely unaffected by the addition of various further measures of previous success and failure such as the biggest win and the biggest loss over all previous rounds.

<sup>11</sup>We do not include dummy variables for winning without a prize interaction as the dummy variables for winning and losing are collinear.

The inclusion of the  $\kappa^M$  and  $\kappa^F$  terms controls for any effect of the current prize on behavior. The variables  $\delta_r^M$  and  $\delta_r^F$  are round-specific intercepts, which control for differential learning and average ability by gender. The term  $\mu_n$  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. Last,  $u_{n,r}$  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. The unobservable  $u_{n,r}$  is assumed to have mean zero and to be uncorrelated over individuals.

The above description 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 ordinary least squares 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, Newey, and Rosen (1988); also see Bossaerts, Plott, and Zame (2007) for an application of generalized method of moments in an experimental setting). Specifically, taking first differences of (1) gives

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

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).

Similarly to Ham, Kagel, and Lehrer (2005) and Costa-Gomes, Huck, and Weizsäcker (2012), we exploit randomization induced by the experimental design to obtain a number of valid instruments for the variables that measure the previous competitive outcomes in the first differenced equations: first, we use the random draws that 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 15 for evidence that supports the assumption that  $u_{n,r}$  is serially uncorrelated). All these instruments are also interacted with a dummy variable for the subject being male.<sup>12</sup> The

<sup>12</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

[Appendix](#) shows that our results are robust to dropping various subsets of these instruments.

## 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.

The large negative estimate of  $\beta_1^F$ , which is significantly different from zero (two-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 ( $\beta_1^M$  is close to zero and not significant). Reflecting the estimate of  $\beta_1^F$ , 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 3–10. In contrast, reflecting that the estimate of  $\beta_1^M$  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  $\beta_1^F$  and  $\beta_1^M$  differ significantly (two-sided  $p = 0.061$  in the preferred specification; two-sided  $p = 0.011$  in specification R4 in the [Appendix](#), which additionally controls for the effects of competitive outcomes three rounds previously<sup>13</sup>), 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.

Our estimate of  $\theta_1^F$  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

---

first difference of the transitory errors, we instrument for these variables in the same way as for competitive outcomes dated  $r - 1$  so as 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>13</sup>As discussed in the [Appendix](#), 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.

TABLE 2. Estimated parameters.

	Preferred Specification		Robustness to 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

Notes: 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.

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

3. We show robustness to our measure of luck by re-estimating the model with the measures of previous monetary winnings and losses expressed relative to expectations, rather than in absolute terms. 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. Because, on average,  $P_{n,r-j} = 0.5$  the coefficients in this alternative specification tend to be higher.

show women's work effort following a loss at prizes of £0.10 and £3.90, respectively.<sup>14</sup> In contrast, our estimate of  $\theta_1^M$  is negative and significantly different from zero (two-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

<sup>14</sup>Note that predicted effort provision at intermediate prizes can be obtained via linear interpolation.

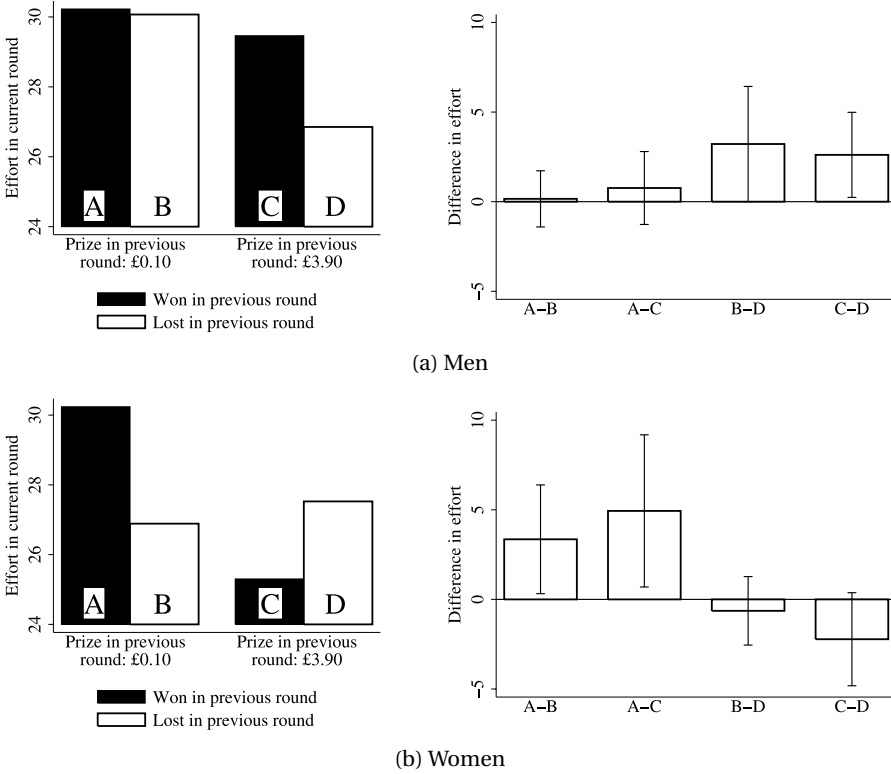


FIGURE 4. Graphical description of the impact of winning or losing in the previous round. *Notes:* The effects are presented for the average male and the average female in round 10, ignoring the contemporaneous prize effect and the impact of winning and losing two rounds previously (by setting  $\kappa^M = \beta_2^M = \gamma_2^M = \theta_2^M = 0$  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. The vertical bars in the right-hand panels represent 95% confidence intervals.

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  $\theta_1^F$  and  $\theta_1^M$  differ significantly (two-sided  $p = 0.043$ ; two-sided  $p = 0.011$  in specification R4 in the [Appendix](#), 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  $\gamma_1^F$ , which is significantly different from zero (two-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 ( $\gamma_1^M$  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  $\gamma_1^F$  and  $\gamma_1^M$  are marginally significantly different from each other (two-sided  $p = 0.082$ ; two-sided  $p = 0.081$  in specification R4 in the [Appendix](#), which additionally controls for the effects of competitive outcomes three rounds previously), which implies a 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  $\beta_1$  and  $\theta_1$  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  $\gamma_1$  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. Additionally, we note here that a  $\chi^2$  test gives  $p = 0.052$  for the joint null that  $\beta_1$ ,  $\theta_1$ , and  $\gamma_1$  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 has a marginally significant negative effect on current effort (negative estimate of  $\beta_2^F$ ; two-sided  $p = 0.090$ ). The effect of the prize conditional on winning also persists for two rounds (negative estimate of  $\gamma_2^F$ ; two-sided  $p = 0.031$ ). In contrast, Table 2 shows that we find no evidence of persistence for men over a two-round horizon. A  $\chi^2$  test gives  $p = 0.458$  for the joint null that  $\beta_2$ ,  $\theta_2$ , and  $\gamma_2$  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 the [Appendix](#), 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.<sup>15</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. To explore the robustness of our results to the measure of luck, we reestimate the model, replacing previous winnings and losses with the value of previous

<sup>15</sup>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.

winnings and losses relative to expectations. The last two sentences in the footnote to Table 2 provide further details. The second column of Table 2 shows that working instead with this purer measure of luck does not materially affect our results.<sup>16</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.

*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 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 the 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.<sup>17</sup> Under this assumption, and with the coefficients on the winning and the 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 3–10, and so approximately 50% of the performance gap is due to the winning and losing effects (the other 50% is due to the gender- and round-specific intercepts, which control for differential learning and average ability by gender).

## 5. DISCUSSION AND 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.

<sup>16</sup>The main difference is that in this alternative specification the evidence for the persistence of the effects for women is weaker.

<sup>17</sup>We need to make such a normalizing assumption because, as noted in footnote 11, the dummy variables for winning and losing are collinear, which means that, independent of the prize, we can only distinguish the difference in behavior between having won and lost a previous round.



In particular, differential responses by gender to winning 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 that 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 (not all subsequent papers have replicated the finding; footnote 3 briefly surveys some of the literature). As yet, beyond informal appeals to evolutionary theory, no convincing mechanism or explanation for this residual dislike for competition has been found. As [Gneezy, Leonard, and List \(2009, p. 1637\)](#) put it, “An important puzzle in this literature relates to the underlying factors responsible for the observed differences in competitive inclinations.”

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 psychophysiological responses that affect behavior in the next round and that vary by gender. The psychophysiology literature has identified differences across gender in how mood ([Mazur, Susman, and Edelbrock \(1997\)](#)), blood pressure ([Holt-Lunstad, Clayton, and Uchino \(2001\)](#)), 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. \(2009\)](#)).<sup>18</sup> [Buser \(2012\)](#) and [Wozniak, Harbaugh, and Mayr \(2010\)](#) linked competition aversion to sex hormones, which also suggests that physiology might be important. On the other hand, [Booth and Nolen \(2012\)](#) and [Gneezy, Leonard, and List \(2009\)](#) linked 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.

Risk aversion or loss aversion, in the standard sense of concave utility over money, cannot explain the negative responses to losing that we observe: due to the concavity, marginal utility would be higher after losing than after winning, and so the incentive to exert effort would be stronger. However, negative responses to losing in a competitive environment could be one instance of a more general negative reaction or aversion to suffering losses, perhaps mediated by the type of psychophysiological responses discussed in the paragraph above. Anticipated differences in such reactions to losses might make women less inclined to take on risk, which would help to explain measured differences in risk aversion by gender (see, e.g., [Charness and Gneezy \(2012\)](#)).

---

<sup>18</sup>An earlier and longer version of this paper discusses this literature and its relationship to our findings in greater detail ([Gill and Prowse \(2010, Section 5.1\)](#)).

Our findings that responses to previous competitive outcomes explain more of the observed variation in the work effort of women and that the impact of wins and losses is also more persistent for women are consistent with the claim that women's behavior exhibits greater context sensitivity. Croson and Gneezy (2009) argued that the greater variability of women's behavior in trust games, dictator games, ultimatum games, and public good games is driven by the fact that women are more context-sensitive than men, where the context includes environmental factors such as the experimental conditions and instructions, social and situational cues, the size of payoffs, social distance, and other players' choices. Bertrand (2011, p. 1554) made the same point regarding gender differences in negotiation.

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).

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, educational environments, and public elections, where competition plays a large role and gender differences in outcomes are apparent, would be invaluable.

#### APPENDIX

In Table 3, we examine the robustness of our results by (i) reestimating the model using different, more restrictive, instrument sets and (ii) estimating the parameters of a model specification that additionally includes variables that describe 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 footnote 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.

In Table 4, we further examine the robustness of our results by (i) reestimating the model including additional variables that measure the rival's effort and the rival's effort interacted with the prize in the current round, and (ii) reestimating the model with additional measures of past competitive outcomes.

TABLE 3. Robustness to choice of instruments (R1–R3) and number of lags (R4).

	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 inclusion of measures of rival's current effort (P1) and additional measures of previous competitive outcomes (P2–P4).

	P1		P2		P3		P4	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
$\beta_1^M$ (Lost round $r - 1$ ; Men)	-0.027	0.847	0.718	1.186	-0.600	0.788	0.135	0.847
$\beta_2^M$ (Lost round $r - 2$ ; Men)	-2.672	1.915	-3.563	2.351	-3.518	2.242	-2.693	2.073
$\beta_1^F$ (Lost round $r - 1$ ; Women)	-3.609**	1.583	-4.240**	1.658	-3.108*	1.768	-3.653**	1.573
$\beta_2^F$ (Lost round $r - 2$ ; Women)	-2.462*	1.308	-2.741**	1.232	-1.979	1.422	-2.386*	1.292
$\gamma_1^M$ (Won round $r - 1 \times$ Prize in round $r - 1$ ; Men)	-0.172	0.282	0.717	0.624	-0.150	0.273	0.229	0.344
$\gamma_2^M$ (Won round $r - 2 \times$ Prize in round $r - 2$ ; Men)	-0.633	0.636	-0.526	0.677	-0.706	0.730	-0.400	0.617
$\gamma_1^F$ (Won round $r - 1 \times$ Prize in round $r - 1$ ; Women)	-1.287**	0.563	-2.109**	0.920	-1.320**	0.551	-1.507**	0.617
$\gamma_2^F$ (Won round $r - 2 \times$ Prize in round $r - 2$ ; Women)	-1.121**	0.496	-1.439**	0.617	-1.080**	0.466	-1.214**	0.519
$\theta_1^M$ (Lost round $r - 1 \times$ Prize in round $r - 1$ ; Men)	-0.895**	0.449	-1.412*	0.748	-0.868**	0.421	-0.744**	0.337
$\theta_2^M$ (Lost round $r - 2 \times$ Prize in round $r - 2$ ; Men)	0.029	0.442	-0.171	0.489	0.115	0.417	0.125	0.366
$\theta_1^F$ (Lost round $r - 1 \times$ Prize in round $r - 1$ ; Women)	0.194	0.281	0.664*	0.403	0.159	0.258	0.304	0.286
$\theta_2^F$ (Lost round $r - 2 \times$ Prize in round $r - 2$ ; Women)	0.166	0.499	0.373	0.490	0.099	0.502	0.203	0.473
$\delta_{10}^M$ (Intercept in round 10; Men)	28.342***	2.188	29.718***	9.301	36.115***	3.321	39.829***	8.104
$\delta_{10}^F$ (Intercept in round 10; Women)	28.935***	1.968	30.606***	4.280	26.324***	4.393	29.847***	5.357
Hansen test (df, $p$ -value)	21.976 (16, 0.144)		14.580 (12, 0.265)		16.970 (14, 0.258)		14.042 (12, 0.298)	
Observations	464		464		464		464	

Notes: All specifications add additional variables to the preferred specification while keeping the instrument set the same. In P1 we add the effort of the Second Mover's rival in the current round  $r$  and the effort of the rival interacted with the prize in the current round. In P2 we add the Second Mover's biggest win and biggest loss over all previous rounds. In P3 we add the number of previous wins. In P4 we add separate variables that measure cumulative winnings over all previous rounds and cumulative losses over all previous rounds. In P2–P4 the coefficients on the additional variables are allowed to vary by gender. Arellano–Bond tests for the null hypothesis of zero second order autocorrelation in the first differenced transitory errors have  $p$ -values of 0.289, 0.177, 0.202, and 0.187 for P1–P4 respectively. See also notes 1 and 2 in Table 2.

Results P1 in Table 4 show that the parameter estimates of the preferred specification are robust to adding variables that measure current-round first mover effort and current-round first mover effort interacted with the current prize. As noted in the [Introduction](#), this shows that our results are not contaminated by the within-round effect studied by [Gill and Prowse \(2012\)](#) whereby the effort of second movers falls in that of their first mover rival.

In specifications P2–P4 in Table 4, we explore the robustness of our results to the addition of various metrics of previous success and failure, beyond wins and losses in the two previous rounds. In summary, we add variables that correspond to the biggest win and the biggest loss over all previous rounds, the number of previous wins, as well as cumulative winnings over all previous rounds and cumulative losses over all previous rounds, and we allow the coefficients on these additional variables to vary by gender. We find that the parameter estimates of the preferred specification in Table 2 are largely unaffected by the inclusion of these additional variables.

Table 5 presents the parameter estimates of the preferred specification for first movers. For female first movers there is only a marginally significant effect on current work effort of last period’s competitive outcome, while for men there is no effect at all. [Footnote 6](#) explains that the first movers face a different situation than that of the sec-

TABLE 5. Estimated parameters (First Movers).

	Preferred Specification	
	Estimate	SE
$\beta_1^M$ (Lost round $r - 1$ ; Men)	-0.982	1.083
$\beta_2^M$ (Lost round $r - 2$ ; Men)	-0.293	1.636
$\beta_1^F$ (Lost round $r - 1$ ; Women)	1.827*	0.988
$\beta_2^F$ (Lost round $r - 2$ ; Women)	-0.198	0.923
$\gamma_1^M$ (Won round $r - 1 \times$ Prize in round $r - 1$ ; Men)	-0.340	0.360
$\gamma_2^M$ (Won round $r - 2 \times$ Prize in round $r - 2$ ; Men)	0.513	0.464
$\gamma_1^F$ (Won round $r - 1 \times$ Prize in round $r - 1$ ; Women)	0.131	0.279
$\gamma_2^F$ (Won round $r - 2 \times$ Prize in round $r - 2$ ; Women)	-0.364	0.232
$\theta_1^M$ (Lost round $r - 1 \times$ Prize in round $r - 1$ ; Men)	0.807	0.515
$\theta_2^M$ (Lost round $r - 2 \times$ Prize in round $r - 2$ ; Men)	0.913**	0.370
$\theta_1^F$ (Lost round $r - 1 \times$ Prize in round $r - 1$ ; Women)	-0.460*	0.240
$\theta_2^F$ (Lost round $r - 2 \times$ Prize in round $r - 2$ ; Women)	-0.493	0.304
$\delta_{10}^M$ (Intercept in round 10; Men)	25.285***	2.806
$\delta_{10}^F$ (Intercept in round 10; Women)	25.382***	1.639
Hansen test (df, $p$ -value)	15.279 (16, 0.504)	
Observations	472	

Notes: The instrument set is as in the preferred specification for Second Movers. An Arellano–Bond test for the null hypothesis of zero second order autocorrelation in the first differenced transitory errors has a  $p$ -value of 0.573. See also the notes to Table 2.

TABLE 6. Average effort and number of observations by gender, competitive outcome in the previous round and prize in the previous round.

	First Movers			
	Men		Women	
	Lost Prev. Round	Won Prev. Round	Lost Prev. Round	Won Prev. Round
Prize in previous round < £1	25.931 (29)	26.762 (21)	26.394 (33)	23.313 (32)
£1 ≤ Prize in previous round < £2	24.654 (26)	27.387 (31)	23.359 (39)	23.833 (30)
£2 ≤ Prize in previous round < £3	23.742 (31)	26.000 (38)	24.872 (47)	24.674 (43)
£3 ≤ Prize in previous round < £4	28.750 (28)	27.267 (30)	23.647 (34)	25.538 (39)
	Second Movers			
	Men		Women	
	Lost Prev. Round	Won Prev. Round	Lost Prev. Round	Won Prev. Round
Prize in previous round < £1	26.185 (27)	27.346 (26)	25.280 (25)	25.167 (36)
£1 ≤ Prize in previous round < £2	26.000 (38)	26.727 (33)	22.500 (22)	25.571 (35)
£2 ≤ Prize in previous round < £3	24.658 (38)	26.838 (37)	23.600 (40)	24.436 (39)
£3 ≤ Prize in previous round < £4	25.125 (32)	26.821 (39)	24.333 (33)	22.636 (22)

Notes: The data are for rounds 2–10. Numbers of observations are in parentheses.

ond movers on a number of dimensions that could influence or moderate the impact of previous wins and losses.

Table 6 presents summary statistics on effort provision by gender, the competitive outcome in the previous round, and the prize in the previous round for both first and second movers. It is important to note that the observed differences in effort provision according to the previous competitive outcome reflect both the causal effect of previous wins and losses on current effort, and the effect of persistent unobservables, such as ability, that are correlated with the measure of previous competitive success. As discussed in footnote 2, our instrumental variables estimation routine allows us to isolate the causal effect of previous competitive outcomes on current effort provision.

## REFERENCES

- Altonji, J. G. and R. M. Blank (1999), “Race and gender in the labor market.” In *Handbook of Labor Economics*, Vol. 3 (O. Ashenfelter and D. Card, eds.), 3143–3259, North-Holland, Amsterdam. [353]
- Arellano, M. and S. Bond (1991), “Some tests of specification for panel data.” *Review of Economic Studies*, 58 (2), 277–297. [361]
- Bertrand, M. (2009), “CEOs.” *Annual Review of Economics*, 1, 121–150. [354]
- Bertrand, M. (2011), “New perspectives on gender.” In *Handbook of Labor Economics*, Vol. 4 (O. Ashenfelter and D. Card, eds.), 1543–1590, North-Holland, Amsterdam. [353, 368]

Bertrand, M. and K. F. Hallock (2001), "The gender gap in top corporate jobs." *Industrial and Labor Relations Review*, 55 (1), 3–21. [354]

Bognanno, M. L. (2001), "Corporate tournaments." *Journal of Labor Economics*, 19 (2), 290–315. [351]

Bonein, A. and L. Denant-Boemont (2011), "Temptation, commitment and peer pressure: A laboratory experiment." Report, University of Rennes. [356]

Booth, A. L. and P. J. Nolen (2012), "Choosing to compete: How different are girls and boys?" *Journal of Economic Behavior and Organization*, 81 (2), 542–555. [367]

Bossaerts, P., C. Plott, and W. R. Zame (2007), "Prices and portfolio choices in financial markets: Theory, econometrics, experiments." *Econometrica*, 75 (4), 993–1038. [361]

Buser, T. (2012), "The impact of the menstrual cycle and hormonal contraceptives on competitiveness." *Journal of Economic Behavior and Organization*, 83 (1), 1–10. [367]

Cason, T. N., W. A. Masters, and R. M. Sheremeta (2010), "Entry into winner-take-all and proportional-prize contests: An experimental study." *Journal of Public Economics*, 94 (9–10), 604–611. [354]

Cettolin, E. and A. Riedl (2011), "Fairness and uncertainty." Report, Maastricht University. [357]

Charness, G. and U. Gneezy (2012), "Strong evidence for gender differences in risk taking." *Journal of Economic Behavior and Organization*, 83 (1), 50–58. [367]

Charness, G. and P. Kuhn (2010), "Lab labor: What can labor economists learn from the lab?" In *Handbook of Labor Economics*, Vol. 4 (O. Ashenfelter and D. Card, eds.), 229–330, North-Holland, Amsterdam. [357]

Charness, G. and M. C. Villeval (2009), "Cooperation and competition in intergenerational experiments in the field and the laboratory." *American Economic Review*, 99 (3), 956–978. [354]

Charness, G., A. Rustichini, and J. van de Ven (2012), "Self-confidence and strategic behavior." Report, UCSB. [354]

Cooper, R., D. V. DeJong, R. Forsythe, and T. W. Ross (1996), "Cooperation without reputation: Experimental evidence from prisoner's dilemma games." *Games and Economic Behavior*, 12 (2), 187–218. [355]

Costa-Gomes, M., S. Huck, and G. Weizsäcker (2012), "Beliefs and actions in the trust game: Creating instrumental variables to estimate the causal effect." Discussion Paper 302, WZB. [353, 361]

Croson, R. and U. Gneezy (2009), "Gender differences in preferences." *Journal of Economic Literature*, 47 (2), 448–474. [368]

Cummins, L. F., M. R. Nadorff, and A. E. Kelly (2009), "Winning and positive affect can lead to reckless gambling." *Psychology of Addictive Behaviors*, 23 (2), 287–294. [352]

Djawadi, B. M. and R. Fahr (2012), "The impact of tax knowledge and budget spending influence on tax compliance." Report, University of Paderborn. [357]

Eacret, N. D., N. C. Lafferty, and T. Jhunjunwala (2011), "When is inequality fair?" Report, University of Texas at Dallas. [357]

Eckel, C. C. (2008), "The gender gap: Using the lab as a window on the market." In *Frontiers in the Economics of Gender*, Siena Studies in Political Economy, 223–242, Routledge, London. [353]

Eriksson, T. (1999), "Executive compensation and tournament theory: Empirical tests on Danish data." *Journal of Labor Economics*, 17 (2), 262–280. [351]

Filaire, E., D. Alix, C. Ferrand, and M. Verger (2009), "Psychophysiological stress in tennis players during the first single match of a tournament." *Psychoneuroendocrinology*, 34 (1), 150–157. [367]

Fischbacher, U. (2007), "z-Tree: Zurich toolbox for ready-made economic experiments." *Experimental Economics*, 10 (2), 171–178. [355]

Fletschner, D., C. Anderson, and A. Cullen (2010), "Are women as likely to take risks and compete? Behavioural findings from Central Vietnam." *Journal of Development Studies*, 46 (8), 1459–1479. [354]

Garratt, R. J., C. Weinberger, and N. Johnson (2013), "The state street mile: Age and gender differences in competition aversion in the field." *Economic Inquiry*, 51 (1), 806–815. [354]

Gill, D. and V. Prowse (2009), "A structural analysis of disappointment aversion in a real effort competition." Discussion Paper 4536, IZA. [352]

Gill, D. and V. Prowse (2010), "Gender differences and dynamics in competition: The role of luck." Discussion Paper 5022, IZA. [355, 367]

Gill, D. and V. Prowse (2011), "A novel computerized real effort task based on sliders." Discussion Paper 5801, IZA. [356]

Gill, D. and V. Prowse (2012), "A structural analysis of disappointment aversion in a real effort competition." *American Economic Review*, 102 (1), 469–503. [352, 356, 357, 371]

Gill, D. and R. Stone (2010), "Fairness and desert in tournaments." *Games and Economic Behavior*, 69 (2), 346–364. [368]

Gill, D., V. Prowse, and M. Vlassopoulos (2013), "Cheating in the workplace: An experimental study of the impact of bonuses and productivity." *Journal of Economic Behavior and Organization*, 96, 120–134. [357]

Gneezy, U. and A. Rustichini (2004), "Gender and competition at a young age." *American Economic Review: Papers and Proceedings*, 94 (2), 377–381. [354]

Gneezy, U., K. L. Leonard, and J. A. List (2009), "Gender differences in competition: Evidence from a matrilineal and a patriarchal society." *Econometrica*, 77 (5), 1637–1664. [354, 367]



- Gneezy, U., M. Niederle, and A. Rustichini (2003), "Performance in competitive environments: Gender differences." *Quarterly Journal of Economics*, 118 (3), 1049–1074. [354]
- Greiner, B. (2004), "An online recruitment system for economic experiments." In *Forschung und Wissenschaftliches Rechnen* (K. Kremer and V. Macho, eds.), GWDG Bericht, Vol. 63, 79–93, GWDG, Göttingen. [355]
- Grund, C. and D. Sliwka (2005), "Envy and compassion in tournaments." *Journal of Economics and Management Strategy*, 14 (1), 187–207. [368]
- Gupta, N. D., A. Poulsen, and M. C. Villeval (2005), "Male and female competitive behavior: Experimental evidence." Discussion Paper 1833, IZA. [354]
- Ham, J. C., J. H. Kagel, and S. F. Lehrer (2005), "Randomization, endogeneity and laboratory experiments: The role of cash balances in private value auctions." *Journal of Econometrics*, 125 (1–2), 175–205. [352, 361]
- Hammermann, A., A. Mohnen, and P. Nieken (2011), "Whom to choose as a team mate? A lab experiment about in-group favoritism." Discussion Paper 6286, IZA. [357]
- Hetzel, S. (2010), *The impact of financial incentives on individual performance: An experimental approach*. Diplomarbeit, University of Mannheim. [356]
- Holt-Lunstad, J., C. J. Clayton, and B. N. Uchino (2001), "Gender differences in cardiovascular reactivity to competitive stress: The impact of gender of competitor and competition outcome." *International Journal of Behavioral Medicine*, 8 (2), 91–102. [367]
- Holtz-Eakin, D., W. Newey, and H. Rosen (1988), "Estimating vector autoregressions with panel data." *Econometrica*, 56 (6), 1371–1395. [361]
- Iriberry, N. and P. Rey-Biel (2012), "Let's (not) talk about sex: Gender awareness and stereotype-threat on performance under competition." Report, Universitat Pompeu Fabra. [354]
- Kamas, L. and A. Preston (2012), "The importance of being confident: Gender, career choice, and willingness to compete." *Journal of Economic Behavior and Organization*, 83 (1), 82–97. [354]
- Kimbrough, E. O. and J. P. Reiss (2012), "Measuring the distribution of spitefulness." *PLoS ONE*, 7 (8), 1–8. [357]
- Kleinjans, K. J. (2009), "Do gender differences in preferences for competition matter for occupational expectations?" *Journal of Economic Psychology*, 30 (5), 701–710. [354]
- Lam, D. and B. Ozorio (2013), "The effect of prior outcomes on gender risk-taking differences." *Journal of Risk Research*, 16 (7), 791–802. [352]
- Lazear, E. P. and S. Rosen (1981), "Rank-order tournaments as optimum labor contracts." *Journal of Political Economy*, 89 (5), 841–864. [352]
- Mazur, A., E. J. Susman, and S. Edelbrock (1997), "Sex difference in testosterone response to a video game contest." *Evolution and Human Behavior*, 18 (5), 317–326. [357, 367]

Monahan, J. (2012), *We're all Lockeans now: A test of the prevalence of just-desert considerations in a dictator game experiment*. M.Phil. thesis, University of Oxford. [357]

Niederle, M. and L. Vesterlund (2007), "Do women shy away from competition? Do men compete too much?" *Quarterly Journal of Economics*, 122 (3), 1067–1101. [354, 367]

Niederle, M., C. Segal, and L. Vesterlund (2013), "How costly is diversity? Affirmative action in light of gender differences in competitiveness." *Management Science*, 59 (1), 1–16. [355]

Ors, E., F. Palomino, and E. Peyrache (forthcoming), "Performance gender-gap: Does competition matter?" *Journal of Labor Economics*. [354]

Riener, G. and S. Wiederhold (2011), "On social identity, subjective expectations, and the costs of control." *Jena Economic Research Papers*, 5, 035. [357]

Roberts, T. A. (1991), "Gender and the influence of evaluations on self-assessments in achievement settings." *Psychological Bulletin*, 109 (2), 297–308. [367]

Thaler, R. H. and E. J. Johnson (1990), "Gambling with the house money and trying to break even: The effects of prior outcomes on risky choice." *Management Science*, 36 (6), 643–660. [352]

Vandegrift, D. and A. Yavas (2009), "Men, women, and competition: An experimental test of behavior." *Journal of Economic Behavior and Organization*, 72 (1), 554–570. [354]

Wolfers, J. (2006), "Diagnosing discrimination: Stock returns and CEO gender." *Journal of the European Economic Association*, 4 (2–3), 531–541. [354]

Wozniak, D. (2012), "Gender differences in a market with relative performance feedback: Professional tennis players." *Journal of Economic Behavior and Organization*, 83 (1), 158–171. [352]

Wozniak, D., W. T. Harbaugh, and U. Mayr (2010), "Choices about competition: Differences by gender and hormonal fluctuations, and the role of relative performance feedback." Report, University of Oregon. [354, 367]

---

Submitted September, 2012. Final version accepted July, 2013.