

oxforddown:
An Oxford University Thesis
Template for R Markdown



Author Name
Your College
University of Oxford

A thesis submitted for the degree of
Doctor of Philosophy
Michaelmas 2018

For Yihui Xie

Acknowledgements

This is where you will normally thank your advisor, colleagues, family and friends, as well as funding and institutional support. In our case, we will give our praises to the people who developed the ideas and tools that allow us to push open science a little step forward by writing plain-text, transparent, and reproducible theses in R Markdown.

We must be grateful to John Gruber for inventing the original version of Markdown, to John MacFarlane for creating Pandoc (<http://pandoc.org>) which converts Markdown to a large number of output formats, and to Yihui Xie for creating `knitr` which introduced R Markdown as a way of embedding code in Markdown documents, and `bookdown` which added tools for technical and longer-form writing.

Special thanks to [Chester Ismay](#), who created the `thesisdown` package that helped many a PhD student write their theses in R Markdown. And a very special thanks to John McManigle, whose adaption of Sam Evans' adaptation of Keith Gillow's original maths template for writing an Oxford University DPhil thesis in LaTeX provided the template that I in turn adapted for R Markdown.

Finally, profuse thanks to JJ Allaire, the founder and CEO of [RStudio](#), and Hadley Wickham, the mastermind of the tidyverse without whom we'd all just given up and done data science in Python instead. Thanks for making data science easier, more accessible, and more fun for us all.

Ulrik Lyngs
Linacre College, Oxford
2 December 2018

Abstract

This *R Markdown* template is for writing an Oxford University thesis. The template is built using Yihui Xie's `bookdown` package, with heavy inspiration from Chester Ismay's `thesisdown` and the `OxThesis` L^AT_EX template (most recently adapted by John McManigle).

This template's sample content include illustrations of how to write a thesis in R Markdown, and largely follows the structure from [this R Markdown workshop](#).

Congratulations for taking a step further into the lands of open, reproducible science by writing your thesis using a tool that allows you to transparently include tables and dynamically generated plots directly from the underlying data. Hip hooray!

Contents

List of Figures	vi
List of Tables	vii
List of Abbreviations	viii
Introduction	1
Why use it?	1
Who should use it?	2
1 Introduction	3
2 Study 1	8
2.1 Methods	8
2.2 Results	11
3 Study 2	13
3.1 Methods	13
3.2 Results	15
4 Discussion	16
Appendices	
A The First Appendix	21
B The Second Appendix, for Fun	22
Works Cited	23

List of Figures

List of Tables

List of Abbreviations

- 1-D, 2-D** . . . One- or two-dimensional, referring **in this thesis** to spatial dimensions in an image.
- Otter** One of the finest of water mammals.
- Hedgehog** . . . Quite a nice prickly friend.

Introduction

Welcome to `oxforddown` (Lyngs 2019), a thesis template for R Markdown that I created when writing [my own PhD thesis](#) at the University of Oxford. This template allows you to write in R Markdown, while formatting the PDF output with the beautiful and time-tested [OxThesis LaTeX template](#). The sample content is partly adapted from [thesisdown](#) .

Hopefully, writing your thesis in R Markdown will provide a nicer interface to the OxThesis template if you haven't used TeX or LaTeX before. More importantly, *R Markdown* allows you to embed chunks of code within your thesis and generate plots and tables directly from the underlying data, avoiding copy-paste steps. This gets you into the habit of doing reproducible research, which will benefit you long-term as a researcher, and also help anyone that is trying to reproduce or build upon your results down the road.

Why use it?

R Markdown creates a simple and straightforward way to interface with the beauty of LaTeX. Packages have been written in **R** to work directly with LaTeX to produce nicely formatting tables and paragraphs. In addition to creating a user friendly interface to LaTeX, *R Markdown* allows you to read in your data, analyze it and to visualize it using **R**, **Python** or other languages, and provide documentation and commentary on the results of your project.

Further, it allows for results of code output to be passed inline to the commentary of your results. You'll see more on this later, focusing on **R**. If you are more into **Python** or something else, you can still use *R Markdown* - see '[Other language engines](#)' in Yihui Xie's *R Markdown: The Definitive Guide*.

Introduction

Using LaTeX together with *Markdown* is more consistent than the output of a word processor, much less prone to corruption or crashing, and the resulting file is smaller than a Word file. While you may never have had problems using Word in the past, your thesis is likely going to be about twice as large and complex as anything you've written before, taxing Word's capabilities.

Who should use it?

Anyone who needs to use data analysis, math, tables, a lot of figures, complex cross-references, or who just cares about reproducibility in research can benefit from using *R Markdown*. If you are working in 'softer' fields, the user-friendly nature of the *Markdown* syntax and its ability to keep track of and easily include figures, automatically generate a table of contents, index, references, table of figures, etc. should still make it of great benefit to your thesis project.

1

Introduction

Women have surpassed men in education outcomes, like college attendance and graduation rates (Blau and Kahn 2017; Goldin et al. 2006; Stoet and Geary 2014), but are still underrepresented in top management positions in nearly all sectors (Bertrand and Hallock 2001) and earn less than men, on average (Blau and Kahn 2017). Traditional economic variables account for some, but not all, of these disparities (Blau and Kahn 2017). As a means of understanding persistent gender gaps in labor market outcomes, researchers have begun to focus on how gender affects one's response to competition (for review, see Niederle and Vesterlund 2011). Seminal work on gender differences in competitiveness operationalized competitiveness as the choice of a tournament payment scheme that reaps potentially higher earnings but requires outperforming an opponent over a piece-rate scheme (Niederle and Vesterlund 2007). This work found that women are less competitive than men, on average, even if they would have earned more by competing (Niederle and Vesterlund 2007).

Follow-up research with nearly identical procedures has replicated the effect of gender on the choice to opt into tournaments (see Niederle and Vesterlund 2011, for review). Notably, this effect has been replicated in diverse populations (e.g., across age groups and cultures) (Apicella and Dreber 2015; Buser, Niederle, et al.

1. Introduction

2014; Sutter, Glätzle-Rützler, et al. 2016; Andersen et al. 2013; Buser, Peter, et al. 2017; Sutter and Rutzler 2010; Dreber et al. 2014; Mayr et al. 2012) and with a diverse set of tasks (Apicella and Dreber 2015; Saccardo et al. 2018; Bjorvatn et al. 2016; Sutter and Glätzle-Rützler 2015; Frick 2011; Samek 2019). Additionally, this laboratory measure of competitiveness predicts labor market outcomes, such as education choices (Buser, Niederle, et al. 2014; Zhang 2012), entrepreneurial decisions [e.g., investment, employment; Berge et al. (2015)], and earnings (Reuben et al. 2015). Thus, competitive preferences may contribute to gender differences in labor market outcomes (Blau and Kahn 2017).

Confidence and risk attitudes have been implicated in driving the gender gap in willingness to compete (Niederle and Vesterlund 2011; van Veldhuizen 2017). However, the extent to which confidence and risk attitudes account for the gender gap in willingness to compete is debated. The seminal research in this literature suggests that confidence and risk attitudes do not completely explain the gender gap in the choice to compete, since there remained a residual gap in the choice to compete after controlling for these factors (Niederle and Vesterlund 2007). The unexplained component of the original gender effect was then taken as evidence of a distinct “competitiveness” trait, separate from risk attitudes and confidence (Niederle and Vesterlund 2007; Niederle and Vesterlund 2011). However, recent work correcting for measurement error (Gillen et al. 2019) and using experimental techniques to isolate the effects of the competitiveness trait (van Veldhuizen 2017) suggests that risk attitudes and confidence may fully explain the gender gap in the choice to compete. Regardless of whether competitiveness is a stand-alone trait, it is clear that confidence and risk attitudes can generate differences in how men and women react to competitions. Thus, interventions designed to increase risk-taking or confidence in women may help reduce the gender difference in competitiveness.

Confidence is conceptualized as the accuracy of one’s perceived performance or ability on a task (Beyer and Bowden 1997). Within the literature on the gender gap in competitiveness, confidence is operationalized as the belief about one’s relative performance during a competition, where individuals who have inaccurately high

1. Introduction

ratings of their performance are deemed overconfident. If an individual does not feel as though their performance is higher than individuals they are competing against, they are unlikely to make the decision to compete for fear of missing the opportunity to earn money, even if they would otherwise outperform their opponent. There is ample research to suggest that women are less (over)confident on average than men across a number of domains (Mobius et al. 2011; Niederle and Vesterlund 2011; Croson and Gneezy 2009; Lundeberg et al. 1994; Niederle and Vesterlund 2007; Bertrand 2010; Beyer 1990; Beyer and Bowden 1997). Though both men and women tend to be overconfident, women are far less likely to fall into the trap of overconfidence, which leads them to compete less often than they should, given their actual ability (Niederle and Vesterlund 2007).

Confidence too may help explain why, in some situations, the gender gap in competitiveness may be reduced or eliminated. For instance, women compete more when tasks are female-typed (i.e., women are expected to perform better based on gender stereotypes) or gender-neutral (Iriberry and Rey-Biel 2017; Boschini, Dreber, von Essen, et al. 2014; Boschini, Dreber, Essen, et al. 2019; Apicella and Dreber 2015; Grosse and Riener 2010; Günther et al. 2010; Dreber et al. 2014; Dreber et al. 2011; Shurchkov 2012) or when they are facing other female opponents (Datta Gupta et al. 2013). Drawing from the psychology literature on stereotype threat (Steele 1997; Spencer, Steele, et al. 1999; Spencer, Logel, et al. 2016), negative stereotypes about women’s ability to perform male-typed tasks (e.g., math, mental rotation) may produce anxiety and undermine performance. As a result, women may decide not to engage in a competition because they either believe the stereotype or because the stereotype provokes enough anxiety to reduce performance (Günther et al. 2010; Grosse and Riener 2010; Iriberry and Rey-Biel 2017; Shurchkov 2012).

Confidence on a task can improve with preparation and training (Gist and Mitchell 1992; Schunk 1981; Schunk 1982; Usher and Pajares 2008), since, in most cases, people are able to observe a gradual improvement in their skills over time. For instance, Lent et al. (1996) found that college students listed past accomplishments as the most influential factor in determining their confidence. Other research

1. Introduction

directly compared the effects of mastery experiences, vicarious experiences (e.g., watching others perform a task), and a control treatment without any intervention on confidence, finding that mastery increased confidence significantly more than vicarious experiences and the control treatment (Bandura et al. 1977). Based on previous evidence of the benefits of enactive mastery through preparation and training on confidence, providing women with an adequate opportunity to prepare before a task may alleviate the gender gap in choice to compete. Surprisingly, little work has explored how preparation differentially impacts men and women’s confidence or their willingness to compete.

A second variable that has been identified as a possible explanation for gender differences in competitiveness is risk attitudes, typically construed as the preference for a certain gain over a gamble, even if the gamble has an equal or greater monetary expectation (Kahneman and Tversky 1982). Several studies across diverse settings have documented a gender difference in risk attitudes, where women tend to be more risk-averse than men on average (Bertrand 2010; Croson and Gneezy 2009; Apicella, Crittenden, et al. 2017). Payment based on the outcomes of a competition are inherently riskier than non-competitive payment schemes (e.g., guaranteed payment per unit of output) because in most cases, there is uncertainty surrounding one’s relative performance (Niederle and Vesterlund 2011).

While recent work suggests that 28% of the gender gap in competitive choices can be explained by risk attitudes (Gillen et al. 2019; van Veldhuizen 2017), other work suggests that risk attitudes play little role in women’s decisions to “self-compete”. That is, risk attitudes do not affect whether women choose to compete against their own past performance, possibly because there is less uncertainty in the decision (Apicella, Demiral, et al. 2017). Thus, to the extent that preparation too can reduce uncertainty in performance, women may be more likely to compete when there are opportunities for preparation.

Notably, both knowing about an opportunity to prepare before competing and the actual act of preparing may encourage high-ability women to enter competitions more often. In knowing one can prepare beforehand, one may assume that they can

1. Introduction

resolve any discrepancies between their current ability and their desired ability level for competition or that they can reduce uncertainty surrounding their performance by preparing. This knowledge, in and of itself, may be sufficient to reduce gender differences in competitiveness, regardless of whether women actually take advantage of this opportunity. Additionally, the act of preparation may be uniquely motivating, since preparation allows an individual to observe an improvement in their performance over time and/or give them an opportunity to observe their performance, which may reduce the perceived uncertainty of competition. As such, women may choose to compete more after preparing for or practicing a task.

Here, we examined the role of preparation on the gender differences in willingness to compete through two experiments. In the first experiment, we tested whether simply knowing that there will be an opportunity to prepare before performing a task affects the gender gap in willingness to compete. That is, we manipulated participants' knowledge of whether they had unlimited time to prepare before they made their decision to compete. We anticipated that participants with this information would be more inclined to compete compared to participants without this information and that this effect would be stronger for women, who tend to be relatively less confident. Thus, we expected an interaction between gender and condition on the choice to compete, along with a main effect of condition. In the second experiment, we examined how actual preparation influences the decision to compete. That is, we manipulated whether participants were required to prepare before making the decision to compete. Again, we expected that women in the preparation condition would be especially inclined to compete. In both experiments, we measured gender differences in actual preparation after administering the treatment and eliciting preferences to compete. Finally, we monetarily incentivized participants in both studies to correctly predict which gender would prepare and compete more. The research design, hypotheses, measures and analyses were preregistered unless otherwise stated and all analyses were conducted in R statistical software (version 4.0.4).

2

Study 1

2.1 Methods

We recruited workers on Amazon Mechanical Turk for Study 1, and those who opted into the study had to pass several screening questions. Specifically, participants included in the paid portion of the study had to (i) identify their nationality as American and live in the United States, (ii) identify as male or female, and (iii) be using a computer (rather than a phone or tablet). If they did not meet these criteria, they did not proceed to the paid portion of the study. Additionally, upon reviewing the data, we had reason to suspect that some participants completed the study more than once. Specifically, some participants had the same IP address, MTurk ID, and were of the same gender. When entries matched on all three identifiers, we included only the first entry and excluded all subsequent entries. The final sample consisted of 1056 participants (53.6% women), with an average age of 37.74 ($SD = 13.19$) years. 54 participants (53.7% women) dropped out of the study before finishing and we use their data when available.

Participants were told they would be completing a multiplication task where they would be able to choose how they would be paid for their performance. We chose a multiplication task because we expect participants will improve with practice. Indeed, research suggests that rehearsing and recalling associative memories can

2. Study 1

speed up retrieval of those memories (Rundus 1971). The task involved solving problems from multiplication tables 1-12 as quickly as possible within a two-minute period. They were provided an example of a question with the correct response and had to answer three practice problems correctly to proceed, as a test of their comprehension. After completing the comprehension questions, participants were randomly assigned to either a “knowledge of preparation” condition or a control condition. Participants in the “knowledge of preparation” condition were presented the following text:

“There is an option to practice/study before completing the multiplication task that is available to all participants. If you take this opportunity to practice/study, we will provide you with materials that may help boost your performance in the multiplication task. You will have unlimited time to practice/study before completing the task. You can stop practicing/studying at any point.”

Participants assigned to the control condition simply proceeded without seeing this text. Then, all participants learned about the two possible payment schemes (either piece-rate or tournament) that they would have the option to choose from and had to correctly answer questions testing their comprehension of the payment schemes.

Under the piece-rate scheme participants were told that they would be paid \$.10 for every problem answered correctly. Under the tournament scheme, participants were told that they would be paid \$.20 for every problem they answered correctly, but only if they answered more questions correctly than a randomly assigned competitor. Participants in the experimental condition were reminded that they had the option to prepare before completing the task. The order of presentation of the tournament and piece-rate payment options was randomized for participants.

After choosing a payment scheme, participants in both conditions were given an opportunity to prepare before the multiplication task. If they chose to prepare, participants were presented with each multiplication table, 1 through 12, in sequential order. Each multiplication table provided products of numbers up to 12. Thus, participants could use the table to study. Additionally, participants were

2. Study 1

asked if they wanted to complete practice problems. If they said yes, participants were asked to solve all multiples in that table and could only proceed to the next table if they answered all the questions correctly.

Once they completed all practice questions for a given times table, they were shown the multiplication table again and were asked if they would like to continue solving problems from that table or move onto the next multiplication table. This process was repeated for each multiplication table. Thus, we had two measures of preparation behavior: the decision to practice and the total number of times participants completed each multiplication table. The decision to practice measure conceptually captures a participants' baseline willingness to prepare, before they know what the preparation will involve. Thereafter, the total number of preparation rounds reflects participants' willingness to repeatedly prepare.

Following the preparation portion of the study, participants moved on to the paid portion of the study. They were required to solve as many problems as possible in two minutes. After completion, participants were told how many problems they answered correctly and completed a series of incentivized follow-up questions, including confidence and perceptions of gender differences. For these measures, participants were told one of these questions would be selected for a possible bonus payment, and if they answered the selected question correctly, they would earn a bonus of \$.10. For the measure of confidence, participants were asked to correctly predict their relative performance compared to all other participants completing the task by indicating the decile of their score. Notably, the item was phrased so participants did not need to understand the word "decile," but were asked instead: "If my performance is compared to that of all participants that completed the task, I think my score was. . ." with the options for responses ranging from "Better than all other participants" to "Better than none of the other participants" with 10% increments in between (e.g., "Better than 50% of participants"). Participants were also asked to correctly predict which gender 1) correctly solved more problems 2) spent more time practicing before completing the multiplication task, and 3) chose the tournament payment option more.

2. Study 1

Finally, participants completed a measure of risk aversion, where they answered if they generally are willing to take risks or try to avoid taking risks (Dohmen and Falk 2011) on a 10 point scale with 0 meaning participants are “Not at all willing to take risks” and 10 indicating participants are “Very willing to take risks.” To determine whether participants used additional tools to improve their performance on the task, we also asked participants about their use of calculators and perceptions of calculator use on the multiplication task. Neither of these measures was incentivized.

2.2 Results

An equal number of participants were assigned to both conditions (control= 50%). Of the males who completed the study, 49.9% were assigned to the control condition. Of the females who completed the study, 50.09% were assigned to the control condition.

A minority of participants (15.41%) chose to compete, contrary to previous data in this literature (Niederle and Vesterlund 2007). Despite the small proportion of participants who chose to compete, we still replicate the gender gap in the choice to compete, where a greater share of men (19.59%) compared to women (10.78%) chose to compete. A logistic regression revealed that this gender difference in the choice to compete is significant, $b = -0.73$, 95% CI $[-1.23, -0.24]$, $z = -2.90$, $p = .004$. Contrary to our predictions, we do not find evidence of a significant interaction between gender and condition on the decision to compete, $b = 0.06$, 95% CI $[-0.63, 0.76]$, $z = 0.18$, $p = .861$ (see Figure ??), suggesting that women in the knowledge of preparation condition were not uniquely more inclined to compete.

As hypothesized, women were 75.47% more likely to take advantage of the opportunity to practice relative to men, $b = 0.56$, 95% CI $[0.31, 0.82]$, $z = 4.37$, $p < .001$, while controlling for the decision to compete (see Figure ??). As an exploratory analysis, we tested whether gender and the choice to compete interact to predict the choice to prepare, but did not find evidence for an interaction, $b = 0.12$, 95% CI $[-0.60, 0.86]$, $z = 0.33$, $p = .740$.

2. Study 1

In further support of gender differences in preparation, women completed 68.59% more rounds of preparation relative to men, $b = 0.52$, 95% CI [0.36, 0.69], $z = 6.14$, $p < .001$ (see Figure ??). Thus, we have evidence that women prepare more both 1) before they know what the preparation entails and 2) after they have had the chance to experience the preparation. One can imagine that these would be driven by distinct psychological mechanisms, where 1) captures whether a person generally takes advantage of any opportunity to prepare, regardless of what it involves, while 2) measures a person's willingness to persist in their preparation, even after exerting effort previously during preparation. The fact that we find gender differences across two different forms of willingness to prepare suggests that the findings are robust. This gender difference aligned with participants' predictions about gender differences in preparation, where participants expected women, relative to men, to spend more time preparing for the multiplication task, $\chi^2(1, n = 1056) = 15.67$, $p < .001$ (see Figure ??), and in general, $\chi^2(1, n = 1056) = 447.11$, $p < .001$ (see Figure ??). One possible explanation for participants' predictions is that they expected men to outperform women on the task, which would lead women to compensate by preparing more. However, participants did not expect any gender differences in performance on the task, $\chi^2(1, n = 1056) = 1.02$, $p = .313$ (see Figure ??). Additionally, participants accurately predicted that women were less likely to choose to compete, $\chi^2(1, n = 1056) = 716.24$, $p < .001$ (see Figure ??), suggesting that they did not believe women prepare more because they were more likely to compete.

3

Study 2

3.1 Methods

Participants were recruited on Amazon Mechanical Turk using the same screening criteria as Study 1. Also, if participants had an identical IP address, MTurkID, and gender, we excluded their second response. The final sample consisted of 1076 participants (50.56% women), with an average age of 38.57 ($SD = 12.52$) years. 62 participants (51.61% women) dropped out of the study before finishing.

As in Study 1, participants included in the study were told they would be completing a two-minute multiplication task (identical to the one used in Study 1) and would be able to choose a payment scheme for their performance. The instructions and payment per question were identical to Study 1. After being told about the rules for the multiplication task and passing the same comprehension questions used in Study 1, participants were assigned to either a preparation condition, where they were told they would complete several rounds of preparation before completing the multiplication task, or a control condition, where they were told they would complete several rounds of a counting task before continuing. Participants were randomly assigned to each condition. The participants in the preparation condition completed 12 rounds (one round per multiplication table), with 6 problems per round. The problems for each round were selected at random.

3. Study 2

Participants in the control condition were asked to complete 5 questions where they counted the number of zeros in a matrix of zeros and ones. After a 30-second break following completion of their respective tasks, all participants chose a payment scheme for the multiplication task, where the order of presentation was counterbalanced. That is, half of participants saw the tournament scheme presented as the first option and half saw the piece-rate payment scheme presented first.

After choosing a payment scheme, participants in both conditions had the option to spend (extra) time preparing for the multiplication task. Again, we had two measures of preparation behavior: the decision to practice and the total number of times participants completed the multiplication table. If they chose to prepare, participants were given two minutes to complete a randomly selected set of problems from all 12 multiplication tables. Once they finished the first two-minute preparation round, participants could opt into 4 more rounds of preparation, each two minutes long, before they moved on to the paid portion of the study.

Then, participants completed the paid multiplication task for two minutes. We included many of the same follow-up questions as in Study 1, including risk aversion, confidence, and perceptions of gender differences in preparation, competitiveness, and performance. Participants were incentivized to answer the questions about their confidence and perceptions of gender differences correctly, and were paid at the same rate as Study 1. We also asked participants if they wished they had more time to prepare for the multiplication task and included measures of their fatigue, field-specific ability beliefs, and interest in the multiplication task all on 1 (Strongly disagree) to 7 (Strongly agree) scales. For the fatigue scale, participants rated how fatigued and mentally exhausted they felt (Milyavskaya et al. 2018). Participants indicated the degree to which they “enjoyed completing the multiplication task” for the interest scale (Milyavskaya et al. 2018). Finally, to measure field-specific ability beliefs, we asked participants how much they perceived success in math depends on ability versus effort through six questions (e.g., “If you want to succeed in math, hard work alone just won’t cut it; you need to have an innate gift or talent”) (Meyer et al. 2015).

3.2 Results

An equal number of participants were assigned to both conditions (control= 50%). Of the males who completed the study, 50% were assigned to the control condition and of the females who completed the study, 50% were assigned to the control condition.

We replicated the effect of gender on the choice to compete: 19.36% of men chose to compete compared to 13.6% of women. However, we do not find evidence of a significant effect of condition on the choice to compete among women, $z = -1$, $p = 0.16$ (see Figure ??), contrary to our hypotheses.

Despite no evidence for the effect of condition on the choice to compete among women, we replicate the effects found in Study 1, where women were significantly more likely to prepare for the task, even after being forced to prepare in the preparation condition (see Figure ??). Women were 18.62% more likely to take advantage of the opportunity to prepare relative to men $b = 0.11$, 95% CI $[-0.39, 0.62]$, $z = 0.45$, $p = .653$, while controlling for the decision to compete (see Figure ??). Again, we find that these results align with participants' expectations, where they were significantly more likely to expect women to choose to prepare in general, $\chi^2(1, n = 1076) = 511.06$, $p < .001$ (see Figure ??), despite expecting men to choose to compete more often, $\chi^2(1, n = 1076) = 578.07$, $p < .001$ (see Figure ??) and expecting no gender differences in performance on the task, $\chi^2(1, n = 1076) = 0.61$, $p = .434$ (see Figure ??).

4

Discussion

Previous research suggests that women tend to be more risk-averse (Croson and Gneezy 2009; Dohmen, Falk, et al. 2011; Eckel and Grossman 2008; Bertrand 2010) and less confident (Bertrand, Goldin, et al. 2010; Lundeberg et al. 1994; Mobius et al. 2011; Barber and Odean 2001; Croson and Gneezy 2009), which affects their decisions to compete. Since confidence and risk attitudes may be affected by the opportunity to prepare, women may be more likely to compete when they have the opportunity to prepare before entering a competition. Through two experiments, we explored whether the opportunity to prepare affects gender differences in competitiveness and whether there are gender differences in willingness to prepare. First, we find no evidence that preparation increases men or women's willingness to compete. However, and notably, we discovered a sizable gender difference in preparation. In study 1, we found that women were 75.47% more likely to choose to practice. We replicated this finding in study 2, where women were 18.62% more likely to practice, even though half of participants were required to prepare for several minutes beforehand. This effect is especially noteworthy since we are drawing from a participant pool (MTurk) where participants could be earning money for their participation through a nearly limitless supply of other studies, so the opportunity costs of preparing may be greater for MTurkers.

4. Discussion

To our knowledge, these studies are the first to demonstrate a gender difference in preparation among adults who must explicitly opt into preparation. However, previous findings within educational contexts *have* found that women are more likely than men to value dedication and mastery (Leslie et al. 2015; Kenney-Benson et al. 2006), emphasize the importance of hard work (Mccrea, Hirt, and Milner 2008; Hirt and Mccrea 2009; Mccrea, Hirt, Hendrix, et al. 2008), and spend more time preparing than men for an intellectual evaluation when they were told that practice improved future performance (Kimble and Hirt 2005). For instance, in a study examining school-aged children’s approach to learning math, researchers found that girls, compared to boys, reported being more motivated to “master” their schoolwork and engage in more effortful learning strategies (Kenney-Benson et al. 2006). In one study looking at whether delaying competition affects gender differences in the willingness to compete while providing opportunity to study, Charness et al. (2020) did not find a significant difference in the choice to prepare ($N = 202$). Although it is worth noting that, though the effect is non-significant, women are directionally more likely to prepare in this study. Since studying gender differences in the choice to prepare was not one of the main foci of their research, contrary to ours, it is entirely possible they did not have sufficient power to detect the effect of gender on the choice to prepare as a result.

The observed gender difference in preparation may be driven by women’s relatively greater desire to reduce uncertainty around their future performance (given their greater average risk aversion) and/or increase their performance (given their lower average confidence). Indeed, mastery is an important driver of confidence (for review, see Gist and Mitchell 1992; Usher and Pajares 2008). While it is possible that confidence and risk aversion may be driving the gender difference in preparation, it is important to note that preparation in our studies did not increase competitiveness in either men or women. Because participants were able to choose to prepare in study 2, we are unable identify whether preparation causally affected confidence and/or risk aversion. Future work should examine the bidirectional relationships between confidence and preparation and risk and preparation. Of

4. Discussion

course, other explanations for the gender differences in preparation may also exist, including relative differences in real or perceived opportunity costs, how rewarding it is to prepare, and/or enjoyment on the task.

Again, we find little evidence that preparation affects willingness to compete. However, it is possible that we may have found an effect of preparation had we given participants unlimited time to prepare so that they mastered the material or reached their desired level of proficiency. In fact, by limiting the amount of time to prepare in study 2, we may have unintentionally undermined confidence. For instance, participants may have been made more aware of the discrepancy between their current ability and their desired ability. Even more, having limited time to prepare may also have been stressful to participants and to offset this stress, some participants may have opted for the less stressful piece-rate payment scheme. Thus, future work examining the role of preparation on competition should examine how unlimited preparation and perceived level of mastery influence decisions to compete.

Finally, we showed that participants accurately predicted the observed gender differences in preparation and competitiveness, regardless of their own choice to prepare or compete, suggesting that they observe these behaviors directly in their own lives and/or have learned about stereotypes surrounding these behaviors. There is extensive work suggesting that beliefs about identity-based behavior actually affect behavior (Babcock et al. 2012; Bowles et al. 2007; Toosi et al. 2019; Smith and Huntoon 2014; Benjamin et al. 2010; Bertrand, Kamenica, et al. 2015; Akerlof and Kranton 2000). Our findings would suggest that any observed gender differences in behavior may be generalizable to other contexts. In both cases, participants' accuracy in predicting the gender differences in competitiveness and preparation would suggest that these are not isolated findings, but in fact are representative of gender differences in other contexts. One step to improve gender equality within organizations is to take these gender differences into account when making decisions on how to organize reward structures and communicate these structures to employees, and to reward cooperation and other forms of work on par with competition.

4. Discussion

While we built off an extensive and laudable literature on gender differences in competitiveness, we have unearthed a new gender difference in preparation. As this is a new area of research, there are many promising and exciting avenues for future exploration, all of which have the potential to inform policy. First, future work should explore whether these results generalize to other populations and tasks. Second, future work should examine the impact of preparation on performance. Do women overprepare? Do men underprepare? What are the opportunity costs to preparing? Also, it would be important to think about ways that women could be equally rewarded *without* having to compete - that is, reimagining how to support women being productive in ways that work for them. And finally, how do competitions themselves affect gender differences in the choice to prepare?

Much of the research on gender differences in competitiveness is focused on designing interventions to increase women's competitiveness, with less attention paid to potential downstream consequences of these interventions. Here we show that preparation has no impact on willingness to compete, while discovering a gender difference in preparation. Future work should explore the implications of these findings further where these effects may have a long-lasting impact on gender differences in economic outcomes.

Appendices



The First Appendix

This first appendix includes an R chunk that was hidden in the document (using `echo = FALSE`) to help with readability:

In 02-rmd-basics-code.Rmd

And here's another one from the same chapter, i.e. Chapter ??:

B

The Second Appendix, for Fun

Works Cited

- Akerlof, George A. and Rachel E. Kranton (2000). “Economics and identity”. In: *The Quarterly Journal of Economics* 115.3, pp. 715–753.
- Andersen, Steffen et al. (2013). “Gender, competitiveness, and socialization at a young age: Evidence from a matrilineal and a patriarchal society”. In: *Review of Economics and Statistics* 95.4, pp. 1438–1443.
- Apicella, Coren L., Alyssa N. Crittenden, and Victoria A. Tobolsky (2017). “Hunter-gatherer males are more risk-seeking than females, even in late childhood”. In: *Evolution and Human Behavior* 38, pp. 592–603.
- Apicella, Coren L., Elif E. Demiral, and Johanna Mollerstrom (2017). “No gender difference in willingness to compete when competing against self”. In: *DIW Discussion Papers*.
- Apicella, Coren L. and Anna Dreber (2015). “Sex differences in competitiveness: Hunter-gatherer women and girls compete less in gender-neutral and male-centric tasks”. In: *Adaptive Human Behavior and Physiology* 1.3, pp. 247–269. DOI: [10.1007/s40750-014-0015-z](https://doi.org/10.1007/s40750-014-0015-z).
- Babcock, Linda, Hannah Riley Bowles, and Julia Bear (2012). “A model of when to negotiate: Why women don’t ask”. In: *The Oxford Handbook of Economic Conflict Resolution*, pp. 313–331. DOI: [10.1093/oxfordhb/9780199730858.013.0022](https://doi.org/10.1093/oxfordhb/9780199730858.013.0022).
- Bandura, Albert, Nancy E Adams, and Janice Beyer (1977). “Cognitive processes mediating behavioral change”. In: *Journal of Personality and Social Psychology* 35.3, pp. 125–139.
- Barber, Brad M. and Terrance Odean (2001). “Boys will be boys: Gender, overconfidence, and common stock investment”. In: *The Quarterly Journal of Economics* 116.1, pp. 261–292.
- Benjamin, Daniel J., James J. Choi, and A. Joshua Strickland (2010). “Social identity and preferences”. In: *American Economic Review* 100.4, pp. 1913–1928. DOI: [10.1257/aer.100.4.1913](https://doi.org/10.1257/aer.100.4.1913). arXiv: [9809069v1](https://arxiv.org/abs/9809069v1) [arXiv:gr-qc].
- Berge, Lars Ivar Oppedal et al. (2015). “Competitive in the lab, successful in the field?”. In: *Journal of Economic Behavior and Organization* 118, pp. 303–317. DOI: [10.1016/j.jebo.2014.11.014](https://doi.org/10.1016/j.jebo.2014.11.014). URL: <http://dx.doi.org/10.1016/j.jebo.2014.11.014>.
- Bertrand, Marianne (2010). “New Perspectives on Gender”. In: *Handbook of Labor Economics*. Vol. 4b, pp. 1545–1592.
- Bertrand, Marianne, Claudia Goldin, and Lawrence F. Katz (2010). “Dynamics of the gender gap for young professionals in the financial and corporate sectors”. In: *American Economic Review* 2.3, pp. 228–255.
- Bertrand, Marianne and Kevin F Hallock (2001). “The gender gap in top corporate jobs”. In: *Industrial and Labor Relations Review* 55, pp. 3–21.

Works Cited

- Bertrand, Marianne, Emir Kamenica, and Jessica Pan (2015). "Gender identity and relative income within households". In: *Quarterly Journal of Economics*, pp. 571–614. DOI: [10.1093/qje/qjv001](https://doi.org/10.1093/qje/qjv001). Advance. arXiv: [arXiv:1011.1669v3](https://arxiv.org/abs/1011.1669v3).
- Beyer, Sylvia (1990). "Gender differences in the accuracy of self-evaluations of performance". In: *Journal of Personality and Social Psychology* 59.5, pp. 960–970. DOI: [10.1037/0022-3514.59.5.960](https://doi.org/10.1037/0022-3514.59.5.960).
- Beyer, Sylvia and Edward M. Bowden (1997). "Gender differences in self-perceptions: Convergent evidence from three measures of accuracy and bias". In: *Personality and Social Psychology Bulletin* 23.2, pp. 157–172.
- Bjorvatn, Kjetil, Ranveig Falch, and Ulrikke Hernæs (2016). "Gender, context and competition: Experimental evidence from rural Uganda". In: *Journal of Behavioral and Experimental Economics* 61, pp. 31–37.
- Blau, Francine D. and Lawrence M Kahn (2017). "The gender wage gap: Extent, trends, and explanations". In: *Journal of Economic Literature* 55.3, pp. 789–865. DOI: [10.1257/jel.20160995](https://doi.org/10.1257/jel.20160995).
- Boschini, Anne, Anna Dreber, Emma Von Essen, et al. (2019). "Gender, risk preferences and willingness to compete in a random sample of the Swedish population". In: *Journal of Behavioral and Experimental Economics* 83.September, p. 101467. DOI: [10.1016/j.socec.2019.101467](https://doi.org/10.1016/j.socec.2019.101467). URL: <https://doi.org/10.1016/j.socec.2019.101467>.
- Boschini, Anne, Anna Dreber, Emma von Essen, et al. (2014). "Gender and economic preferences in a large random and representative sample". In: *SSRN Electronic Journal*. DOI: [10.2139/ssrn.2443315](https://doi.org/10.2139/ssrn.2443315). URL: <http://papers.ssrn.com/abstract=2443315>.
- Bowles, Hannah Riley, Linda Babcock, and Lei Lai (2007). "Social incentives for gender differences in the propensity to initiate negotiations: Sometimes it does hurt to ask". In: *Organizational Behavior and Human Decision Processes* 103, pp. 84–103. DOI: [10.1016/j.obhdp.2006.09.001](https://doi.org/10.1016/j.obhdp.2006.09.001).
- Buser, Thomas, Muriel Niederle, and Hessel Oosterbeek (2014). "Gender, competition and career choices". In: *The Quarterly Journal of Economics* 129.3, pp. 1409–1447. DOI: [10.1093/qje/qju009](https://doi.org/10.1093/qje/qju009). Advance.
- Buser, Thomas, Noemi Peter, and Stefan C Wolter (2017). "Gender, competitiveness, and study choices in high school: Evidence from Switzerland". In: *American Economic Review: Papers & Proceedings* 107.5, pp. 125–130.
- Charness, Gary, Lien Dao, and Olga Shurchkov (2020). "Competing now and then: The effects of delay and the vanishing gender gap in competitiveness". In: *SELL Journal* 5.1, p. 55.
- Croson, Rachel and Uri Gneezy (2009). "Gender differences in preferences". In: *Journal of Economic Literature* 47.2, pp. 448–474. DOI: [10.1257/jel.47.2.448](https://doi.org/10.1257/jel.47.2.448). URL: <http://pubs.aeaweb.org/doi/10.1257/jel.47.2.448>.
- Datta Gupta, Nabanita, Anders Poulsen, and Marie Claire Villeval (2013). "Gender matching and competitiveness: Experimental evidence". In: *Economic Inquiry* 51.1, pp. 816–835. DOI: [10.1111/j.1465-7295.2011.00378.x](https://doi.org/10.1111/j.1465-7295.2011.00378.x).
- Dohmen, Thomas and Armin Falk (2011). "Performance pay and multidimensional sorting: Productivity, preferences, and gender". In: *American Economic Association* 101.2, pp. 556–590. DOI: [http://dx.doi.org/10.1016/j.poly.2014.08.015](https://doi.org/10.1016/j.poly.2014.08.015).
- Dohmen, Thomas, Armin Falk, et al. (2011). "Individual risk attitudes: Measurement, determinants, and behavioral consequences". In: *Journal of the European Economic Association*

Works Cited

- Association* 9.3, pp. 522–550. DOI: [10.1111/j.1542-4774.2011.01015.x](https://doi.org/10.1111/j.1542-4774.2011.01015.x). arXiv: [arXiv:1011.1669v3](https://arxiv.org/abs/1011.1669v3).
- Dreber, Anna, Emma Von Essen, and Eva Ranehill (2011). “Outrunning the gender gap — boys and girls compete equally”. In: *Experimental Economics* 14.4, pp. 567–582. DOI: [10.1007/s10683-011-9282-8](https://doi.org/10.1007/s10683-011-9282-8).
- (2014). “Gender and competition in adolescence: Task matters”. In: *Experimental Economics* 17, pp. 154–172. DOI: [10.1007/s10683-013-9361-0](https://doi.org/10.1007/s10683-013-9361-0).
- Eckel, Catherine C and Philip J Grossman (2008). “Men, women, and risk aversion: Experimental evidence”. In: *Handbook of Experimental Economics*. Vol. 1, pp. 1061–1073. DOI: [10.1016/S1574-0722\(07\)00113-8](https://doi.org/10.1016/S1574-0722(07)00113-8).
- Frick, Bernd (2011). “Gender differences in competitiveness: Empirical evidence from professional distance running”. In: *Labour Economics* 18.3, pp. 389–398. DOI: [10.1016/j.labeco.2010.11.004](https://doi.org/10.1016/j.labeco.2010.11.004). URL: <http://dx.doi.org/10.1016/j.labeco.2010.11.004>.
- Gillen, Ben, Erik Snowberg, and Leeat Yariv (2019). “Experimenting with measurement error: Techniques with applications to the Caltech cohort study”. In: *Journal of Political Economy* 127.4, pp. 1826–1863.
- Gist, Marilyn E and Terence R Mitchell (1992). “Self-efficacy: A theoretical analysis of its determinants and malleability”. In: *The Academy of Management Review* 17.2, pp. 183–211.
- Goldin, Claudia, Lawrence F Katz, and Ilyana Kuziemko (2006). “The homecoming of American college women: The reversal of the college gender gap”. In: *Journal of Economic Perspectives* 20.4, pp. 133–156. DOI: [10.1257/jep.20.4.133](https://doi.org/10.1257/jep.20.4.133). URL: <http://pubs.aeaweb.org/doi/10.1257/jep.20.4.133>.
- Grosse, Niels and Gerhard Riener (2010). “Explaining gender differences in competitiveness: Gender-task stereotypes”. In: *Jena economic research papers*.
- Günther, Christina et al. (2010). “Women can’t jump?—An experiment on competitive attitudes and stereotype threat”. In: *Journal of Economic Behavior and Organization* 75.3, pp. 395–401. DOI: [10.1016/j.jebo.2010.05.003](https://doi.org/10.1016/j.jebo.2010.05.003).
- Hirt, Edward R and Sean M Mccrea (2009). “Man smart, woman smarter ? Getting to the root of gender differences in self-handicapping”. In: *Social and Personality Psychology Compass* 3, pp. 260–274.
- Iriberry, Nagore and Pedro Rey-Biel (2017). “Stereotypes are only a threat when beliefs are reinforced: On the sensitivity of gender differences in performance under competition to information provision”. In: *Journal of Economic Behavior and Organization* 135, pp. 99–111.
- Kahneman, Daniel and Amos Tversky (1982). “The psychology of preferences”. In: *Scientific American* 246.1, pp. 160–173.
- Kenney-Benson, Gwen A et al. (2006). “Sex differences in math performance: The role of children’s approach to schoolwork”. In: *Developmental Psychology* 42.1, pp. 11–26. DOI: [10.1037/0012-1649.42.1.11](https://doi.org/10.1037/0012-1649.42.1.11).
- Kimble, Charles E and Edward R Hirt (2005). “Self-focus, gender, and habitual self-handicapping: Do they make a difference in behavioral self-handicapping?” In: *Social Behavior and Personality* 33.1, pp. 43–56.
- Lent, Robert W. et al. (1996). “Cognitive assessment of the sources of mathematics self-efficacy: A thought-listing analysis”. In: *Journal of Career Assessment* 4.1, pp. 33–46. DOI: [10.1177/106907279600400102](https://doi.org/10.1177/106907279600400102).

Works Cited

- Leslie, Sarah-Jane et al. (2015). “Expectations of brilliance underlie gender distributions across academic disciplines”. In: *Science* 347.6219, pp. 23–34. DOI: [10.1081/E-EWS](https://doi.org/10.1081/E-EWS).
- Lundeberg, Mary A, Paul W Fox, and Judith Puncochaf (1994). “Highly confident but wrong: Gender differences and similarities in confidence judgments”. In: *Journal of Educational Psychology* 86.1, pp. 114–121.
- Lyngs, Ulrik (2019). *oxforddown: An Oxford University Thesis Template for R Markdown*. <https://github.com/ulyngs/oxforddown>. DOI: [10.5281/zenodo.3484682](https://doi.org/10.5281/zenodo.3484682).
- Mayr, Ulrich et al. (2012). “Competitiveness across the life span: The feisty fifties”. In: *Psychology and Aging* 27.2, pp. 278–285. DOI: [10.1037/a0025655](https://doi.org/10.1037/a0025655).
- Mccrea, Sean M, Edward R Hirt, Kristin L Hendrix, et al. (2008). “The worker scale: Developing a measure to explain gender differences in behavioral self-handicapping”. In: *Journal of Research in Personality* 42, pp. 949–970. DOI: [10.1016/j.jrp.2007.12.005](https://doi.org/10.1016/j.jrp.2007.12.005).
- Mccrea, Sean M, Edward R Hirt, and Bridgett J Milner (2008). “She works hard for the money: Valuing effort underlies gender differences in behavioral self-handicapping”. In: *Journal of Experimental Social Psychology* 44, pp. 292–311. DOI: [10.1016/j.jesp.2007.05.006](https://doi.org/10.1016/j.jesp.2007.05.006).
- Meyer, Meredith, Andrei Cimpian, and Sarah-Jane Leslie (2015). “Women are underrepresented in fields where success is believed to require brilliance”. In: *Frontiers in Psychology* 6, pp. 1–12. DOI: [10.3389/fpsyg.2015.00235](https://doi.org/10.3389/fpsyg.2015.00235).
- Milyavskaya, Marina et al. (2018). “More effort, less fatigue: How interest increases effort and reduces mental fatigue”. In: .
- Mobius, Markus M et al. (2011). “Managing self-confidence: Theory and experimental evidence”. In: *NBER Working Paper*.
- Niederle, Muriel and Lise Vesterlund (2007). “Do women shy away from competition? Do men compete too much?” In: *The Quarterly Journal of Economics* 122.3, pp. 1067–1101. URL: <https://web.stanford.edu/%7B~%7Dniederle/Niederle.Vesterlund.QJE.2007.pdf>.
- (2011). “Gender and competition”. In: *Annual Review of Economics* 3, pp. 601–630. DOI: [10.1016/j.labeco.2009.08.002](https://doi.org/10.1016/j.labeco.2009.08.002).
- Reuben, Ernesto, Paola Sapienza, and Luigi Zingales (2015). “Taste for competition and the gender gap among young business professionals”. In: *NBER WORKING PAPER SERIES*.
- Rundus, Dewey (1971). “Analysis of rehearsal processes in free recall”. In: *Journal of Experimental Psychology* 89.1, pp. 63–77.
- Saccardo, Silvia, Aniela Pietrasz, and Uri Gneezy (2018). “On the size of the gender difference in competitiveness”. In: *Management Science* 64.4, pp. 1541–1554.
- Samek, Anya (2019). “Gender differences in job entry decisions: A university- wide field experiment”. In: *Management Science* 65.7, pp. 3272–3281.
- Schunk, Dale H (1981). “Modeling and Attributional Effects on Children’s Achievement: A Self-Efficacy Analysis”. In: *Journal of Educational Psychology* 73.1, pp. 93–105.
- (1982). “Progress Self-Monitoring: Effects on Children’s Self-Efficacy and Achievement”. In: *The Journal of Experimental Education* 51.2, pp. 89–93.
- Shurchkov, Olga (2012). “Under pressure: Gender differences in output quality and quantity under competition and time constraints”. In: *Journal of the European Economic Association* 10.5, pp. 1189–1213.

Works Cited

- Smith, Jessi L and Meghan Huntoon (2014). "Women's Bragging Rights: Overcoming Modesty Norms to Facilitate Women's". In: *Psychology of Women Quarterly* 38.4, pp. 447–459. DOI: [10.1177/0361684313515840](https://doi.org/10.1177/0361684313515840).
- Spencer, Steven J., Christine Logel, and Paul G. Davies (2016). "Stereotype Threat". In: *Annual Review of Psychology* 67.1, pp. 415–437. DOI: [10.1146/annurev-psych-073115-103235](https://doi.org/10.1146/annurev-psych-073115-103235). URL: <http://www.annualreviews.org/doi/10.1146/annurev-psych-073115-103235>.
- Spencer, Steven J., Claude M. Steele, and Diane M. Quinn (1999). "Stereotype threat and women's math performance". In: *Journal of Experimental Social Psychology* 35.1, pp. 4–28. DOI: [10.1006/jesp.1998.1373](https://doi.org/10.1006/jesp.1998.1373).
- Steele, Claude M. (1997). "A threat in the air: How stereotypes shape intellectual identity and performance". In: *American Psychologist* 52.6, pp. 613–629. DOI: [10.1037/0003-066X.52.6.613](https://doi.org/10.1037/0003-066X.52.6.613).
- Stoet, Gijsbert and David C Geary (2014). "Sex differences in academic achievement are not related to political, economic, or social equality". In: *Intelligence* 48, pp. 137–151. DOI: [10.1016/j.intell.2014.11.006](https://doi.org/10.1016/j.intell.2014.11.006). URL: <http://dx.doi.org/10.1016/j.intell.2014.11.006>.
- Sutter, Matthias and Daniela Glätzle-Rützler (2015). "Gender differences in the willingness to compete emerge early in life and persist". In: *Management Science* 61.10, pp. 2339–2354. DOI: [10.1287/mnsc.2014.1981](https://doi.org/10.1287/mnsc.2014.1981). URL: <http://pubsonline.informs.org/doi/10.1287/mnsc.2014.1981>.
- Sutter, Matthias, Daniela Glätzle-Rützler, et al. (2016). "Cancelling out early age gender differences in competition: an analysis of policy interventions". In: *Experimental Economics* 19.2, pp. 412–432. DOI: [10.1007/s10683-015-9447-y](https://doi.org/10.1007/s10683-015-9447-y).
- Sutter, Matthias and Daniela Rutzler (2010). "Gender differences in competition emerge early in life". In: *Working Papers in Economics and Statistics*.
- Toosi, Negin R et al. (2019). "Who can lean in? The intersecting role of race and gender in negotiations". In: *Psychology of Women Quarterly* 43.1, pp. 7–21. DOI: [10.1177/0361684318800492](https://doi.org/10.1177/0361684318800492).
- Usher, Ellen L and Frank Pajares (2008). "Sources of self-efficacy in school: Critical review of the literature and future directions". In: *Review of Educational Research* 78.4, pp. 751–796. DOI: [10.3102/0034654308321456](https://doi.org/10.3102/0034654308321456).
- Van Veldhuizen, Roel (2017). "Gender differences in tournament choices: Risk preferences, overconfidence or competitiveness?" In: *Discussion Paper* 14.
- Zhang, Y. Jane (2012). "Can experimental economics explain competitive behavior outside the lab?" In: *Unpublished manuscript*, pp. 1–45. DOI: [10.2139/ssrn.2292929](https://doi.org/10.2139/ssrn.2292929).