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The role of overconfidence in overweighting private information: Does gender matter?

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Abstract

This paper analyzes gender differences of overweighting private information in a social learning game. The results show that male participants’ fraction of choosing in line with private signal is significantly higher than female, i.e. men are more likely to follow their own private information than women. This gender effect is primarily salient in the incongruent rounds where a participant receives a private signal that is against with majority of the public information. However, no significant gender differences of overweighting private information are found in the congruent rounds where a participant receives a private signal that matches with majority of public information. In addition, we find that overweighting private information is positively correlated with overconfidence; men are more overconfident than women; a mediation analysis reveals that overconfidence explains the gender differences of overweighting private information.

Keywords: overweighting private information; gender; overconfidence

JEL Classification numbers: C91; D81

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1. Introduction

In many social and economic situations, individuals are influenced by the thoughts or behaviors of others (Cialdini and Goldstein, 2004; Raafat et al., 2009). Social psychologists, using the line-judgment conformity experiments (Asch, 1951), have illustrated how the judgments of others influence individuals’ behaviors and emphasized that conformity behavior is mainly driven by maintaining or building acceptance. In principle, an individual’s behavior is based on private and public information. Private information is an individual’s own information others have not obtained. In contrast, the individual can also consider information that is commonly available to everyone, this is public information.

Importantly, theoretical and empirical work in economics has shown that in a situation where decision makers have imperfect information about the true state of the world, it can be rational to disregard their own private information and make decisions based on what are believed to be more informative public signals. In particular, if decisions are made sequentially and the earlier decisions become public information, herding behaviors can occur. Such a pattern of herding is called “information cascades” (Banerjee, 1992; Bikhchandani et al., 1992; Anderson and Holt, 1997).

However, experimental studies on information cascades in social learning games have documented that individuals tend to overweight private information relative to the public information that is conveyed by the choices of others (a literature review about information cascades refers to Weizsäcker, 2010). For example, Huck and Oechssler (2000) provided experimental evidence that the rule that described participants’
behavior best was following one’s own signal. Goeree et al. (2007) reported experimental results from long sequences of decisions and found that subjects tended to overweight private signals, alternatively, underweight the publicly-observed choices.\(^1\) In addition, Nöth and Weber (2003) documented that putting too much weight on private information was due to the heuristic of overconfidence, i.e., overconfidence provided the potential explanation for one’s overweighing private information.\(^2\) Innocenti et al. (2010) and Angrisani et al. (2018) also provided laboratory evidence that overweighing private information resulted from overconfidence.

The above literature suggests that individuals tend to assign more weight to private information, and this behavior can be explained by overconfidence. However, less known is how overconfidence impacts the overweighing private information between genders. In this paper, we investigate the gender difference regarding the degree of overweighing private information, and how overconfidence impacts the overweighing private information differently for women and men. Such a comparison is important since there is widespread gender imbalance in business and finance environments. Thus, a better understanding of the gender differences in overweighing private information has important implications for the design of decision-making processes in business, finance and other economic settings.

Previous studies have found that there are significant gender differences in overconfidence. For example, Barber and Odean (2001) showed that men were more

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1 Other papers that have found similar results see Kraemer et al. (2006), Çelen and Kariv (2004), Kübler and Weizsäcker (2004), and Grebe et al. (2008).

2 Other explanations, such as advanced error correction, regret aversion and gambler’s fallacy were inconsistent with their data.
overconfident than women in trading stocks. Using a large set of exam data, Bengtsson et al. (2005) found that there were significant gender differences in exam behavior; male students tended to be more inclined than female students to aim for a higher grade, indicating men had more overconfidence than women. Dahlbom et al. (2011) also found that male students were overconfident about their grades, whereas female students were underconfident.

Therefore, we hypothesize that because of men having more overconfidence than women, male participants would assign more weight to private information than female participants. To test our hypothesis, we follow the design of Niu et al. (2019) and conduct three experiments (one main experiment, and two additional experiments). Specifically, participants in the main experiment as well as in the first additional experiment are at the fixed position to predict which of two equally-likely events (A or B box) has happened after observing the predecessors’ predictions. This design makes it easy to compare overweighting private information across genders. 3 We also manipulate the congruency between participants’ private signal and predecessors’ predictions (Huck and Oechssler, 2000; Grebe et al., 2008). In the congruent condition, participants’ private signal matches with majority of predecessors’ predictions, while in the incongruent condition it is not. The gender differences of overweighting private information in the incongruent or congruent condition can thus be separately examined.

We find that men’s fraction of choosing in line with private signal is significantly higher than women, i.e. men assign more weight to private information than women. In

3 We also conduct an additional experiment in which subjects are not at the fixed position, please see the second additional experiment.
addition, overconfidence is positively correlated with the fraction of choosing in line with private signal. Men are more overconfident than women. A mediation analysis indicates that the gender differences of overweighting private information is partially mediated by overconfidence. In addition, for robustness checks we conduct two additional experiments. In the first additional experiment, we change the order of (in)consistent public information, and participants’ position. In the second experiment, we design some short sequences of decisions. Our additional two experiments show that the gender differences of overweighting private information are robust.

Our paper complements experimental literature on information cascades in social learning games. Using a meta data set of 13 experimental studies on information cascades, Weizsäcker (2010) showed that participants failed to learn from others since they underestimated their predecessors’ choices. Ziegelmeyer et al. (2010) experimentally demonstrated that information endowment affected overweighting private information, i.e. low informed participants tended to herd without regard to their private information whereas high informed participants always chose in line with their private information. Fahr and Irlenbusch (2011) analyzed the differences between individual and small group as decision makers in social learning games, and found that groups disregarded their own private signals more often than individuals if it was rational to do so. Parys and Ash (2018) experimentally tested the effect of group identity on sequential decision-making. They found that subjects were more likely to follow choices of in-group than out-group predecessors. We contribute to the literature by experimentally examining the gender differences in overweighting private information,
and find that men are more likely to follow their own private information than women.4

Our paper also complements psychological literature on the gender differences in social influence or conformity. Social psychological studies have established that women are more easily influenced than men (a meta-analysis see Eagly and Carli, 1981; and also see Bond and Smith, 1996). However, Rosander and Eriksson (2012) explored gender differences of conformity behavior in use of the Internet and found that men showed a higher level of conformity than women. Our paper uses a social learning game to investigate gender differences of overweighting private information. Compared with psychological paradigms (e.g. the line-judgment task by Asch, 1951), the social learning game requires participants not only weigh evidence of public information from the predecessors’ predictions, but also weigh their own private signal (Anderson and Holt, 1997). Importantly, it is rational for participants to disregard their own private information and follow the prediction of the predecessors when private information conflicts with public information. Our results show that men assign more weight to private information, and they may thus exhibit less conformity behavior than women.

The paper proceeds as follows. Section 2 describes the details of the main experiment. In Section 3, we describe the rational benchmark using the Bayesian Nash Equilibrium (BNE) concept. Section 4 presents the results for the main experiment. In Section 5 we run two additional experiments to examine whether our results are robust. We draw conclusions in Section 6.

4 Some of the other extensions involve information cascades in online movie rating (Lee et al., 2015), revolutionary regime transitions (Ellis and Fender, 2011) and stock trading in financial markets (Alevy et al., 2007).
2. Experimental Design and Procedure

Our experiment design is based on Niu et al. (2019). In the experiment, the main unit of analysis is defined as a “round”, where a group of eight persons are arranged in random order and incentivized to predict the uncertain state of the world. The predictions or choices made by the persons are announced publicly. The order of persons is indexed by $P_i, i \in [1,8]$. In each round, there are two possible states of the world, $S \in \{A \text{ box}, B \text{ box}\}$ and the prior probability of each state is $\frac{1}{2}$. Each person’s task is to determine which state of the world is more likely. To do so, on his turn each person receives a conditionally independent private signal $s \in \{a \text{ ball}, b \text{ ball}\}$ such that $\Pr (s = a \mid S = A) = \Pr (s = b \mid S = B) = \frac{2}{3}$, and sees the predictions or choices of all predecessors. In the experiment instructions, the states of the world are denoted as $A$ box and $B$ box, and the private signals are either $a$ ball or $b$ ball; each of the two boxes $(A, B)$ contains 3 balls ($a$ or $b$), with the $A$ box including two $a$ balls and one $b$ ball and the $B$ box including one $a$ ball and two $b$ balls.

At the beginning of each round, one of the boxes ($A$ or $B$) is randomly chosen with equal probabilities (i.e. 0.5). The first person ($P1$) then draws one ball ($a$ or $b$) from the box and makes a choice, which would be showed to every member of the group. Afterwards, the second person ($P2$) draws his or her private signal, and in addition, $P1$’s choice is showed again. As before, $P2$ has to decide between $A$ and $B$ box, followed by a feedback to every group member. Each subsequent turn proceeds in this manner with persons always receiving predictions or choices made by predecessors from the current
round. Each round is ended after all the eight persons making their choices.

Following Spiwoks et al. (2008), the seven predecessors (P1–P7) are not physically present during the experimental sessions, but they have given their responses in a pilot session recorded beforehand. However, all the seven predecessors agree that their responses could be reused in other sessions. All participants in the experimental sessions acting as P8 are required to make a prediction or choice after observing their private signals (a ball or b ball) and the seven predecessors’ choices (A box or B box). The participants are informed that P1 to P7 have also received their own conditionally independent private signals by drawing a ball from the same box.

Figure 1. Time course of a single round. At the beginning of each round, a participant is presented with the current round number followed by choices made by P1 to P7. Once a participant presses the “Begin” button, P1’s choice is displayed on the screen. Two seconds later, P2’s choice is displayed, and so on. The seven predecessors’ choices are displayed sequentially, and the interval between displaying every two persons’ choices is fixed at 2 seconds. 14 seconds after all the seven predecessors’ choices are displayed, P8 draws a ball by pressing the “Draw ball” button. At last, P8 makes a choice after observing his or her private signal.

The procedure of a single round is depicted in Figure 1. Each round presents the predictions or choices made by P1 to P7 at the center of the computer screen in a
sequential order with an interval of two seconds between displaying every two persons’
predictions. After all the seven predecessors’ predictions have been displayed, $P_8$
presses the “Draw ball” button to receive his or her private signal. Once $P_8$ receives his
or her private signal ($a$ or $b$), $P_8$ has to make a prediction of which box ($A$ or $B$) he or
her draws the ball ($a$ or $b$) from.

In total the participants ($P_8$) complete 6 rounds in which his or her private signal
is matched with majority of the seven predecessors’ choices, and 6 rounds in which his
or her private signal is against with majority of the seven predecessors’ choices. The 12
rounds are presented in a random order.

In order to explore the differing weights given to private and public information
between genders, we follow Frydman and Krajbich (2018) and define a variable called
the Net Public Information for $P_i$ as

$$NPI_i = (-1)^{i} \sum_{N=1}^{7} (1_{A,N} - 1_{B,N}), \quad i \in [1,7].$$

The first term ($(-1)^{i}$) is 1 if $P_i$ receives private signal $a$, and −1 otherwise. The second
term ($\sum_{N=1}^{7} (1_{A,N} - 1_{B,N})$) is the difference between the number of observed “$A$” choice (or
box) and that of “$B$” choice. $NPI_i > 0$ indicates that $P_i$ receives a congruent private
signal while $NPI_i < 0$ indicates an incongruent private signal. $NPI$ has six different
values in our main experiment, which are 1, 3, and 5 in the congruent condition and −1,
−3, and −5 in the incongruent condition. For example, if there are 2 predecessors who
have chosen $B$ box, the other 5 predecessors have chosen $A$ box, and a participant ($P_8$)
has received $a$ ball, the $NPI = 3$; while the $NPI = −3$ if a participant ($P_8$) has received
$b$ ball.
We create a design matrix (2 × 3 × 2 = 12 rounds) (See Table 1) by using all combinations of condition (incongruent vs. congruent), absolute NPI (the difference between the number of “A” choice and “B” choice) (5 vs. 3 vs. 1), and P8’s ball type (a vs. b). To reduce errors in the comparison of overweighting private information, P1–P7’s choices and participants’ positions are fixed. Despite the potential disadvantages in using the same seven predecessors’ predictions and positions for all participants, we think that the benefit of easily comparing participants’ overweighting private information outweighs the cost of the manipulation.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Absolute NPI</th>
<th>P1–P7’s choices (box)</th>
<th>P8’s private signal (ball)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(NPI&lt;0)</td>
<td></td>
<td>B-B-A-B-B-B-B</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B-B-A-A-B-B-B</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B-B-A-B-B-B-B</td>
<td>b</td>
</tr>
<tr>
<td>(NPI&gt;0)</td>
<td></td>
<td>B-B-A-B-B-B-B</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A-B-A-A-B-B-B</td>
<td>b</td>
</tr>
</tbody>
</table>

A total of one hundred and five undergraduate students (52 males, 53 female) participated in one of seven sessions. Based on calculations made using G*Power (Faul et al., 2009), the final sample size achieved 80% power to detect a median large effect size $d = 0.5$. The experimental sessions were run at Nankai University during March and May of 2019. No subject participated in more than one session of the experiment. The participants’ ages ranged from 19 to 24 years (M=21.25; SD=1.26). A written
informed consent prior to the experiment was offered to the participants; and they received a compensation of 5 yuan plus what they won in the task at the end of the experimental task. The average payoff was 35 yuan.

The entire experiment comprises of 12 rounds. At the end of the experiment, the true state in all the 12 rounds are revealed and those who have predicted correctly receive 5 yuan and 0 yuan otherwise for each round. The experiment is programmed in z-Tree (Fischbacher, 2007).5

After participants have finished the experimental task, we collect the individual-level measure of overconfidence (in particular overprecision) following Ren and Croson (2013). Participants need to answer ten general-knowledge questions that requiring numerical answers by giving 90% confidence intervals for each question. Example questions are “Length of the Nile River (in miles)” or “Martin Luther King’s age at death (in years)”. That is, participants are asked to give a low and a high estimate of the answer such that the true answer will lie within their range 90% of the time.

If participants are well calibrated, the true answer should lie within their confidence intervals for 9 of the 10 questions. However, if a participant exhibits overconfidence, the true answer lies within their confidence interval would be less than 9. Thus, the measurement of overconfidence is calculated the number of questions for which the true answer lies in the range provided by the participant and subtract this number from 9. Participant with a higher number exhibits a more overconfidence. A correctly calibrated participant would have an overconfidence score of 0, whereas an

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5 The full experimental instructions are available in the online Appendix.
extremely overconfidence participant would have an overconfidence score of 9.

3. Bayesian Nash Equilibrium (BNE)

As a rational benchmark, we first describe the solution to the experiment using the Bayesian Nash Equilibrium (BNE) concept. This analysis follows directly from Anderson and Holt (1997).

The first person (P1), whose only information is his or her own private signal, will predict A box if he receives an a ball and B box if a b ball is received. Thus, P1 reveals his private signal (e.g., a ball) as public information (e.g., A box). If P2 receives a private signal (e.g., a ball) that matches P1’s choice (e.g., A box), P2 will reveal his or her private signal as public information by stating the A box also. If P2 receives a private signal (e.g., b ball) that does not match P1’s choice (e.g., A box), this will result in a posterior probability of \( \frac{1}{2} \) because the prior probability is \( \frac{1}{2} \) and the sample is balanced. Thus, P2 will likely state that he draws from the B box since his private signal was b. If P3 observes both P1 and P2 choosing the same box (e.g., A box), and P3 receives a b ball, P3 will respond to an inferred sample of a balls on the first two draws and the b ball on his or her own draw. Let \( n \) be the number of relevant signals a, and \( m \) the number of relevant signals b. Bayes’ rule can be used to calculate the posterior probability of event A:

\[
Pr(A|n,m) = \frac{Pr(n,m|A)Pr(A)}{Pr(n,m|A)Pr(A) + Pr(n,m|B)Pr(B)}
\]

Since the boxes are equally likely a priori, and the sample favors box A, the
posterior probability of $A$ is greater than $\frac{1}{2}$. $P3$ chooses $A$ box in spite of his private signal. This sets off an information cascade, with players $i = 4, \ldots, 8$ adopting the same logic and selecting action $A$ regardless of their own private signals. In sum, according to the prediction of the BNE theory, all persons should choose same state of the world, independent of their private signals, as soon as one state of the world receives on net two decisions in its favor (when $NPI<0$). Importantly, this means that it is rational for all participants to cease their belief updating at this point.

It may be not easy for participants to calculate the Bayes’ posterior probabilities. But participants as $P8$ can simply count the numbers of observed “$A$” choices (or boxes) and those of “$B$” choices to approximate optimal decision making in this situation.\textsuperscript{6} That is, if participants have received a congruent private signal ($NPI>0$) it is rational to follow the private signal. However, when participants have received an incongruent private signal ($NPI<0$), it is not rational to follow the private signal, i.e. overweighting private information.\textsuperscript{7}

4. Results for Main Experiment

We first perform a mixed-design ANOVA on individual choice with condition,

\textsuperscript{6} Guarino et al. (2011) develop a model of aggregate information cascades where the entire history of individual decisions is not observed. In this model, participants are not aware of their own position in the sequence, and are only informed about the total number of others who have chosen the observable choice before them. The authors argue that in this situation a cascade on the observable choice would arise, but a cascade on the unobservable choice would never arise. In our experiment, the entire history of individual decisions is observed. However, the number of $A$ and $B$ box can be counted by subjects, which helps them make a better decision.

\textsuperscript{7} In the main experiment, a participant could update his or her beliefs after receiving a private signal, which should correspond to six posterior probabilities in the different $NPI$ values. Specifically, the posterior probability is 0.0588 ($NPI = -5$), 0.2 ($NPI = -3$), and 0.5 ($NPI = -1$) in the incongruent rounds, and 0.8 ($NPI = 1$), 0.9412 ($NPI = 3$), and 0.9846 ($NPI = 5$) in the congruent rounds.
absolute NPI, and P8’s ball type as within-subject factors and gender as a between-subject factor. Individual choice is coded as a dummy variable and is set to 1 if a participant makes a choice in line with his or her own private signal and 0 otherwise. Significant main or interaction effects are further pursued by Bonferroni-Corrected post hoc tests.8

The mixed-design ANOVA shows that there are significant main effects of condition \([F(1, 103) = 509.50, p < 0.001, \eta^2_p = 0.832]\) and gender \([F(1, 103) = 9.73, p = 0.002, \eta^2_p = 0.086]\), as well as significant condition \(\times\) gender interaction effect \([F(1, 103) = 11.37, p < 0.001, \eta^2_p = 0.099]\). Post hoc tests indicate that the fraction of choosing in line with private information in the congruent condition is significantly higher than the incongruent condition (M_{congruent} = 97.29\%, SE_{congruent} = 0.81\%; M_{incongruent} = 34.36\%, SE_{incongruent} = 2.64\%; p < 0.001, Cohen’s \(d = 2.10\)), and men have a significantly higher fraction of choosing with private signal than women (M_{men} = 69.71\%, SE_{men} = 4.07\%; M_{women} = 61.95\%, SE_{women} = 2.96\%; p = 0.002, Cohen’s \(d = 0.61\)).

Importantly, we find that men’s fraction of choosing in with private signal in incongruent condition where NPI<0 (M = 42.94\%, SE = 3.57\%) is significantly higher than women (M = 25.78\%, SE = 3.53\%) (\(p = 0.001, Cohen’s \(d = 0.66\)), but there are no significant gender differences of choosing in line with private signal in congruent condition where NPI>0 (M_{men} = 98.11\%, SE_{men} = 1.15\%; M_{women} = 96.47\%, SE_{women} = 1.16\%; \(p = 0.222, Cohen’s \(d = 0.19\)) (see Figure 2).

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8 All reported p-values are two-tailed. The p-values are corrected for multiple comparisons. A \(p<0.05\) was considered significant.
Figure 2. Male and female participants’ fraction of choosing in line with private signal in incongruent condition (Panel A) and congruent condition (Panel B) for the main experiment.

We also analyze men and women’s fraction of choosing with private signal in the different NPI. Consistent with the ANOVA analysis, the gender differences of choosing in line with private signal only hold for rounds where $NPI < 0$ ($NPI = -5$: $\bar{M}_{men} = 29.81\%$, $SE_{men} = 5.40\%$; $\bar{M}_{women} = 10.37\%$, $SE_{women} = 3.40\%$. $NPI = -3$: $\bar{M}_{men} = 30.77\%$, $SE_{men} = 5.21\%$; $\bar{M}_{women} = 13.20\%$, $SE_{women} = 3.99\%$. $NPI = -1$: $\bar{M}_{men} = 68.27\%$, $SE_{men} = 5.15\%$; $\bar{M}_{women} = 53.77\%$, $SE_{women} = 5.17\%$) (all $p < 0.01$). For $NPI > 0$, men and women subject almost always choose in line with their own private signal ($NPI = 1$: $\bar{M}_{men} = 97.11\%$, $SE_{men} = 0.94\%$; $\bar{M}_{women} = 97.16\%$, $SE_{women} = 2.47\%$. $NPI = 3$: $\bar{M}_{men} = 94.23\%$, $SE_{men} = 3.53\%$; $\bar{M}_{women} = 99.05\%$, $SE_{women} = 2.48\%$. $NPI = 5$: $\bar{M}_{men} = 98.07\%$, $SE_{men} = 0.96\%$; $\bar{M}_{women} = 98.11\%$, $SE_{women} = 2.09\%$) (all $p > 0.50$).
Figure 3 depicts the distribution of overconfidence score conditioned by genders. The histograms of Figure 3 show that 67.31% men exhibit overconfidence scores between 5 and 9 (Panel A), whereas only 33.96% women fall in this category (Panel B). On average, men’s overconfidence score is 5.596 (SE = 0.265) and women’s overconfidence score is 4.094 (SE = 0.200); male participants have a significant higher overconfidence scores than female [t (103) = -4.531, p < 0.001, Cohen’s d = 0.88], hence men are more overconfident than women.

In addition, we find that participants’ level of overconfidence is positively correlated with the fraction of choosing in line with private signal (Spearman’s rho = 0.296, p = 0.002), i.e. participants with a higher level of overconfidence assign more weight to private information. Specifically, for the incongruent rounds where NPI<0 there is a positive correlation between overconfidence and fraction of choosing in line with private signal (Spearman’s rho = 0.275, p = 0.004), but for the congruent rounds where NPI>0 the correlation is not significant (Spearman’s rho = -0.018, p = 0.853).

To further assess the effect of gender differences in the fraction of choosing in line
with private signal, we run several OLS regressions in which we define *men* as dummy variables that is set to 1 if the participant is a man (see Table 2). *Overconfidence* is participants’ overconfidence scores ranging from 0 to 9. The dependent variable of model (1) and (2) is the fraction of choosing in line with private signal in the 12 rounds. The dependent variable of model (3) and (4) is the fraction of choosing in line with private signal in the incongruent rounds (*NPI*<0). The dependent variable of model (5) and (6) is the fraction of choosing in line with private signal in the congruent rounds (*NPI*>0).

Table 2. OLS regression with robust standard errors (clustering at the individual level). Standard errors are presented in parentheses. **, * indicates significance at 1%, 5% level.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Fraction of choosing in line with private signal</th>
<th>All</th>
<th>NPI&lt;0</th>
<th>NPI&gt;0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td><em>Men</em></td>
<td></td>
<td>0.077** (0.024)</td>
<td>0.048* (0.024)</td>
<td>0.171** (0.050)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.019* (0.008)</td>
<td>0.116* (0.050)</td>
<td></td>
</tr>
<tr>
<td><em>Overconfidence</em></td>
<td></td>
<td>0.619** (0.014)</td>
<td>0.541** (0.357)</td>
<td>0.257** (0.296)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.050)</td>
<td>(0.005)</td>
<td></td>
</tr>
<tr>
<td><em>Constant</em></td>
<td></td>
<td>0.086</td>
<td>0.146</td>
<td>0.102</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>R</em>²</td>
<td></td>
<td>0.086</td>
<td>0.146</td>
<td>0.102</td>
</tr>
<tr>
<td><em>N</em></td>
<td></td>
<td>105</td>
<td>105</td>
<td>105</td>
</tr>
</tbody>
</table>

In model (1), the coefficient of *men* is 0.077 and significant at 1% level. That is, men on average have a significant higher fraction of choosing in line with private signal. If we include the overconfidence in model (2), we find that the coefficient of *men* becomes smaller (0.048), but it is still significant at 5% level. It turns out that the coefficient of *overconfidence* is 0.019 and significant at 5% level, indicating overconfidence has a positive effect on fraction of choosing in line with private signal.
These results are robust in model (3) and (4) where the dependent variable is the fraction of choosing in line with private signal in the incongruent rounds ($NPI<0$). However, in model (5) and (6) the coefficients of men and overconfidence are all not significant, indicating gender and overconfidence do not affect the fraction of choosing in line with private signal in the congruent rounds ($NPI>0$).

At last, we examine whether the gender differences in overweighting private information are mediated by levels of overconfidence. We use model 4 of Hayes’ (2013) PROCESS in SPSS 25. We include men as the independent variable, fraction of choosing in line with private signal as the dependent variable, and overconfidence as mediator. Following Preacher and Hayes (2004), we use 5,000 iterations to derive a 95% confidence interval for the total indirect effect as well as the indirect effect for each mediator. Results reveal that overconfidence has a significant indirect effect (indirect effect = 0.053, 95% CI: 0.036 to 0.079). These results indicate that the gender differences in the fraction of choosing in line with private signal are partially mediated by the participants’ overconfidence. Again, the mediation effect is exclusively evident in the incongruent rounds ($NPI<0$) (indirect effect = 0.075, 95% CI: 0.040 to 0.112), but not present in the congruent rounds ($NPI>0$) (indirect effect = 0.003, 95% CI: −0.012 to 0.019).

5. Robustness Checks

In the main experiment, we find that male participants assign more weight to private information than female; participants’ levels of overconfidence and tendency to
overweighting private information are positively correlated, and men are more overconfident than women; moreover, participants’ overconfidence mediates the gender differences in overweighting private information. In this section, we run robustness checks by conducting two additional experiments.

5.1 First Additional Experiment

One potential concern of our main experiment is whether the gender differences of overweighting private information are robust, when we change the order of public information, and when we change participants’ position. To answer these questions, we conduct a first additional experiment in which we vary the order of public information which is consistent (or inconsistent) with private information. We also change participants’ position to P7.

Specifically, in the first additional experiment we define a variable called order of (in)consistent public information, which is the order of public information consistent with the private signal in the incongruent condition or inconsistent with the private signal in the congruent condition. For example, P7’s private signal (ball) is b, if the P1 to P6’s choices (box) are B-A-A-A-A-A then the order of consistent public information is in the anterior; if the P1 to P6’s choices (box) are A-A-A-A-A-B then the order of consistent public information is in the posterior. Another example is that P7’s private signal (ball) is a, then if the P1 to P6’s choices (box) are B-A-A-A-A-A then the order of inconsistent public information is in the anterior; if the P1 to P6’s choices (box) are A-A-A-A-A-B then the order of inconsistent public information is in the posterior.
Table 3. Six predecessors’ choices used in the first additional experiment

<table>
<thead>
<tr>
<th>Condition</th>
<th>Absolute NPI</th>
<th>Order of (in)consistent public information</th>
<th>P1–P6’s choices (box)</th>
<th>P7’s private signal (ball)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Middle</td>
<td>B-B-A-B-B-B</td>
<td>b</td>
</tr>
<tr>
<td>Incongruent</td>
<td>4</td>
<td>Anterior</td>
<td>B-B-B-B-A-A</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Middle</td>
<td>A-A-B-B-B-B</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anterior</td>
<td>B-B-A-A-A-B-B</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posterior</td>
<td>A-A-A-B-B-B-B</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Middle</td>
<td>A-A-B-A-A-A</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anterior</td>
<td>B-B-B-B-B-B</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anterior</td>
<td>B-B-B-B-B-B</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posterior</td>
<td>A-A-B-B-B-B-A</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anterior</td>
<td>B-B-A-A-A-B-B</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anterior</td>
<td>B-B-B-B-B-A-A</td>
<td>b</td>
</tr>
<tr>
<td>Congruent</td>
<td>2</td>
<td>Middle</td>
<td>A-A-B-B-A-A</td>
<td>a</td>
</tr>
<tr>
<td>(NPI&gt;0)</td>
<td></td>
<td>Anterior</td>
<td>B-B-B-B-B-A-A</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anterior</td>
<td>B-B-A-B-B-B-B</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anterior</td>
<td>B-B-A-B-B-B-B</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posterior</td>
<td>A-A-B-B-B-B-A</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anterior</td>
<td>B-B-B-B-B-A-A</td>
<td>b</td>
</tr>
</tbody>
</table>

By using all combinations of condition, absolute NPI, order of (in)consistent public information, and P7’s private signal, a design matrix (2 × 2 × 3 × 2 = 24 rounds, see Table 3) is created. Therefore, a total of 24 rounds are included in this additional experiment.

In addition, all participates in this additional experiment act as P7 and are required to make a prediction or choice after observing their private signal (a ball or b ball) and the six predecessors’ choices (A box or B box). All other aspects of the experimental design and procedure are identical to the main experiment.

Forty-seven students (23 males, 24 female) from Nankai University were recruited to participate in the first additional experiment. Based on calculations made using
G*Power (Faul et al., 2009), the final sample size achieved 80% power to detect a median large effect size $d = 0.5$. Participants’ ages ranged from 19 to 27 years ($M=21.72$; $SD=2.32$). The average payoff was 44 yuan.

A mixed-design ANOVA on individual choice with condition, absolute NPI, order of (in)consistent public information, and $P8$’s ball type as within-subject factors and gender as a between-subject factor is performed. In line with the main experiment, a significant main effect of condition [$F(1, 45) = 262.61, p < 0.001, \eta_p^2 = 0.854$], and gender [$F(1, 45) = 4.541, p = 0.039, \eta_p^2 = 0.092$], as well as an interaction effect of condition $\times$ gender [$F(1, 45) = 4.92, p = 0.032, \eta_p^2 = 0.098$] are found.

Post hoc tests indicate that men have a significantly higher fraction of choosing in line with private signal than women ($M_{men} = 64.31\%, SE_{men} = 2.70\%; M_{women} = 56.25\%, SE_{women} = 2.64\%; p < 0.01$, Cohen’s $d = 0.62$). Specifically, for the incongruent condition, male participants have a higher fraction of choices consistent with their private signals ($M = 31.88\%, SE = 5.82\%$) than the female participants ($M = 13.54\%, SE = 5.70\%$) ($p < 0.01$, Cohen’s $d = 0.65$). But for the congruent condition male and female participants do not differ ($M_{men} = 96.74\%, SE_{men} = 1.64\%; M_{women} = 98.95\%, SE_{women} = 1.60\%$) ($p = 0.338$, Cohen’s $d = 0.27$).

We also find a marginal significant interaction effect between order of (in)consistent public information and gender [$F(1, 45) = 3.16, p = 0.052, \eta_p^2 = 0.126$]. Compared with female, male participants are more likely to make a choice in line with the private signal when the order of (in)consistent public information is in the anterior ($M_{men} = 63.58\%, SE_{men} = 3.10\%; M_{women} = 55.73\%, SE_{women} = 3.04\%$), middle ($M_{men} = 20$
67.93%, SE\textsubscript{men} = 3.19%; M\textsubscript{women} = 55.73%, SE\textsubscript{women} = 3.13%), and posterior (M\textsubscript{men} = 61.41%, SE\textsubscript{men} = 2.85%; M\textsubscript{women} = 57.29%, SE\textsubscript{women} = 2.78%).

Therefore, consistent with the main experiment we find that male participants have a significantly more fraction of choices choosing in line with their private signals, indicating men assign more weight to private information than women. This result shows that the gender differences of overweighting private information are robust, when we change the order of (in)consistent public information, and when we change participants’ position.

5.2. Second Additional Experiment

The above two experiments are long sequence of decisions, i.e. participants act as \textit{P8} or \textit{P7}. Compared with short sequence of decisions, Goeree et al. (2007) indicated that long sequence of decisions had several features, such as there was almost a complete absence of pure cascades. In addition, Guarino and Jehiel (2013) showed that participants had a tendency of assigning more weight to the early public information. Thus, another potential concern is whether gender differences of overweighting private information is still present in the short sequence of decisions. To address this concern, we conduct a second additional experiment in which several short sequences of decisions are designed.

Specifically, in the second additional experiment a design matrix (2 × 2 × 2 = 8 rounds, see Table 4) is created by using combinations of condition (\textit{NPI} = −2 vs. \textit{NPI} = 2), position (\textit{P3} vs. \textit{P5}), and private signal (\textit{a} vs. \textit{b}). All other aspects of the experimental design and procedure are identical to the main experiment.
Fifty-nine students (30 males, 29 female) from Nankai University were recruited to participate in the second additional experiment. Based on calculations made using G*Power (Faul et al., 2009), the final sample size achieved 80% power to detect a median large effect size $d = 0.5$. Participants’ ages ranged from 19 to 27 years ($M = 21.71; \ SD = 1.58$). The average payoff was 18 yuan.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Predecessors’ choices (box)</th>
<th>Private signal (ball)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$NPI=-2$</td>
<td>$A-A$</td>
<td>$b$</td>
</tr>
<tr>
<td></td>
<td>$B-B$</td>
<td>$a$</td>
</tr>
<tr>
<td></td>
<td>$A-B-B-B$</td>
<td>$a$</td>
</tr>
<tr>
<td></td>
<td>$B-A-A-A$</td>
<td>$b$</td>
</tr>
<tr>
<td>$NPI=2$</td>
<td>$A-A$</td>
<td>$a$</td>
</tr>
<tr>
<td></td>
<td>$B-B$</td>
<td>$b$</td>
</tr>
<tr>
<td></td>
<td>$A-B-B-B$</td>
<td>$b$</td>
</tr>
<tr>
<td></td>
<td>$B-A-A-A$</td>
<td>$a$</td>
</tr>
</tbody>
</table>

A mixed-design ANOVA on individual choice with condition, position, and ball type as within-subject factors and gender as a between-subject factor is performed. We find that there are significant main effect of condition $[F(1, 57) = 305.39, p < 0.001, \eta^2_p = 0.843]$, and gender $[F(1, 57) = 5.436, p = 0.023, \eta^2_p = 0.087]$, as well as interaction effect of condition $\times$ gender $[F(1, 57) = 5.704, p = 0.020, \eta^2_p = 0.091]$. Other main effects and interaction effects are not significant. Men have a significantly higher fraction of choosing in line with private signal than women ($M_{men} = 65.83\%, \ SE_{men} = 2.69\%; \ M_{women} = 56.90\%, \ SE_{women} = 2.73\%; \ p = 0.023, \text{Cohen’s } d = 0.61$). Specifically, in the incongruent condition male participants have a higher fraction of choices consistent with their private signals ($M = 38.33\%, \ SE = 4.82\%)$ than the female participants ($M = 20.69\%, \ SE = 4.90\%)$ ($p = 0.013, \text{Cohen’s } d = 0.67$). However, the
fraction of choices choosing in line the private signals between genders do not differ in the congruent condition ($M_{\text{men}} = 93.733\%$, $SE_{\text{men}} = 2.06\%$; $M_{\text{women}} = 93.10\%$, $SE_{\text{women}} = 2.10\%$) ($p = 0.938$, Cohen’s $d = 0.01$). These results indicate that the gender differences of overweighting private information are robust in the short sequence of decisions.

6. Conclusion

This paper reports data from social learning games to investigate the gender differences of overweighting private information. We find that men have a significantly higher fraction of choosing in line with private information than women, which is primarily driven by men assigning more weight to private signal than women in the incongruent rounds ($NPI<0$). This result is robust in the two additional experiments.

In addition, we test the potential psychological mechanism for the gender effect by collecting post-experiment questionnaires. Previous study has found that men are more overconfident than women (Barber and Odean, 2001; Bengtsson et al., 2005). Overweighting private information is associated with the degree of overconfidence (Innocenti et al., 2010; Nöth and Weber, 2003). Thus, the gender differences of overconfidence may explain the gender effect. Our data confirm this conjecture. We find that the propensity to choose in line with private information when $NPI<0$ is positively correlated with overconfidence. Men are more overconfident than women. A further mediation analysis shows that overconfidence explains the gender differences.

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9 It may reflect a ceiling effect, as the number of choices consistent with private signals in the congruent rounds ($NPI>0$) is very high.
in overweighting private information. Overconfidence is one of potential psychological mechanisms for overweighting private information.

Our experimental data complements psychological studies on the gender difference in social influence or conformity. We find that men are more likely to follow own private signal and exhibit less conformity than women in the social learning games. This result has important implications for environments with room for social learning. For example, our experiment results suggest that women investors in financial markets might be better able to infer the right information from the actions of other investors than men investors, indicating it may be beneficial to encourage women investors participate financial market (Eckel and Füllbrunn, 2015).

References


