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Research article

Gender differences in the tendency to follow private information: Evidence from a social learning game

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ABSTRACT

This paper experimentally examines gender differences in the tendency to follow private information in a social learning game. The experimental results show that the proportion of decisions made by male participants that are consistent with their private signals is significantly higher than that of female participants, i.e., men are more likely to follow their own private information than women. This gender effect is primarily present when participants' private signals contradict the majority of public information. Overconfidence is a mechanism underlying the gender effect.

1. Introduction

Herding is a form of convergent social behavior that can be defined as the alignment of the thoughts or behaviors of individuals in a group. 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 for them to disregard their own private information and make decisions based on what are believed to be more informative public signals (which is referred to as "social learning"). In particular, if decisions are made sequentially and the earlier decisions become public information, herding behaviors can occur; such patterns of herding are called "information cascades" (Banerjee, 1992; Bikhchandani et al., 1992; for a recent review of information cascades, see Bikhchandani et al., 2024).

However, experimental studies of information cascades in a social learning game have documented that individuals tend to follow their private information relative to the public information that is conveyed by the choices of others (Weizsäcker, 2010). For example, Huck and Oechssler (2000) provided experimental evidence that the rule that best described subjects' behavior was to follow their own private signals. Çelen and Kariv (2004) conducted a laboratory experiment and found that subjects tended to disregard the information revealed by the actions of their predecessors and follow their own private information. Goeree et al. (2007) reported experimental results from long decision sequences and found that subjects tended to follow their private information.[1]

Several papers have suggested that the tendency to follow private information may be due to overconfidence (Innocenti et al., 2010; Nöth & Weber, 2003; Angrisani et al., 2021). Innocenti et al. (2010) used eye-tracking to trace the process of attention during the social learning game and provided evidence that gaze direction was driven by overconfidence. They found that overconfident subjects, whose actual decisions overrated their own private information, exhibited a tendency to initially look at their private information,

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[1] Other papers that have found similar results include Kübler and Weizsäcker (2004), Kraemer et al. (2006), and Grebe et al. (2008).

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although their total allocation of attention was distributed evenly between private and public information. Bayesian subjects, whose actual choices correctly considered both private and public information, however, uniformly allocated gaze direction both initially and totally. Nöth and Weber (2003) conducted a laboratory experiment and found that subjects' overconfidence led to fewer than expected information cascades. They argued that overconfidence provided the only consistent explanation for the tendency to follow private information, and other explanations (e.g., advanced error correction, regret aversion, and gambler's fallacy) were inconsistent with their data. Angrisani et al. (2021) experimentally tested whether the overconfidence model and the redundancy of information neglect model capture subjects' behaviors.[2] The results of their experiment were supportive of the overconfidence model and at odds with the redundancy of information neglect model.

The above studies suggest that individuals tend to follow private information, and this behavior can be explained by overconfidence. However, less well known is how overconfidence affects the tendency to follow private information between women and men. In this paper, we use a social learning game to investigate gender differences in the tendency to follow private information. In fact, a high tendency to follow private signals would result in fewer information cascades than predicted by the theory. For this reason, studying gender differences to improve our understanding of the tendency to follow private information can provide important insights into information cascades.

While both men and women exhibit overconfidence, men are generally more overconfident than women. For example, Barber and Odean (2001) showed that men were more 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.

Therefore, we hypothesize that because men are more overconfident than women, male subjects are more likely to follow their private information than female subjects. To test this hypothesis, we conduct a series of experiments. In our experiments, we use a social learning game first introduced by Anderson and Holt (1997) and then widely used to study the tendency to follow private information (Grebe et al., 2008; Huck & Oechssler, 2000; Innocenti et al., 2010; Niu et al., 2019; Nöth & Weber, 2003).

The experimental results show that the proportion of decisions made by men that are in line with the private signal is significantly higher than that of women, i.e., men are more likely to follow their private information than women. This gender effect is only present when a participant receives a private signal that does not match most of the public information. However, the gender effect is not found when a participant receives a private signal that matches most of the public information. The gender effect is robust to the order of (in) consistent public information and to the position of the participants, and it is also present in the short decision sequences and when participants are general people. The gender effect also remains robust regardless of whether the public information is presented sequentially or all at once. We also provide suggestive evidence that overconfidence is a mechanism underlying the gender effect.

Our paper complements the experimental literature on information cascades in the social learning game. Using a meta-data set of thirteen experimental studies on information cascades, Weizsäcker (2010) showed that subjects failed to learn from others since they underestimated their predecessors' choices. Ziegelmeyer et al. (2010) experimentally demonstrated that information endowment affected the tendency to follow 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 individuals and small groups as decision makers in the social learning game. They found that groups disregarded their own private signals more often than individuals if it was rational to do so. Amini et al. (2016) compared the degree of conformity in groups with varying gender compositions. Their experimental data showed little evidence that gender composition affected the expression of minority views. Van Parys and Ash (2018) experimentally tested the effect of group identity on sequential decision-making. They found that subjects were more likely to follow the choices of their in-group than of out-group predecessors. We contribute to the literature by examining the gender differences in the tendency to follow private information and show that men are more likely to follow their own private information than women.

2. Experiment 1

Experiment 1 is designed to provide an initial test of gender differences in the tendency to follow private information. In Experiment 1, participants are asked to play a sequential decision task (i.e., the social learning game) in which they are in the eighth position to predict which of two equally likely events has occurred in the presence of known predictions made by seven previous participants. This design makes it easy to compare the tendency to follow private information between women and men.

2.1. Method

2.1.1. Participants

Based on the average effect sizes (i.e., Cohen's $d = 0.57$) from Amini et al. (2016), which examined the influence of gender

[2] The redundancy of information neglect model implied that signals observed by earlier predecessors had more influence than signals observed by later predecessors (Eyster & Rabin, 2010). That is, subjects interpreted a predecessor's action as if it simply reflected the predecessor's private information, thus the subjects failed to account that their predecessors had already incorporated earlier signals in their decisions.

composition on conformity behavior, we used G*power 3.1.9.2 to run an a priori power analysis for independent-samples *t*-tests (Faul et al., 2009).[3] The priori power analysis suggested a stopping criterion of 100 participants as a reasonable estimate to achieve 80 % power two-tailed (with an alpha level of 0.05). We thus recruited 105 undergraduate students (52 male, 53 female) from Nankai University via flyers and e-mails. The participants' ages ranged from 19 to 24 years ($M = 21.25$; $SD = 1.26$).

All participants provided written informed consent according to protocols approved by the ethical board of the university, and they received a compensation of 5 Chinese yuan plus what they won in the task at the end of the experiment. The average payoff was about 35 Chinese yuan. Experiment 1 was a laboratory experiment and was conducted between March and May 2019. No subject participated more than once. In our experiments, we reported all measures, manipulations, and exclusions.

2.1.2. Design and procedure

Our experimental design closely follows Niu et al. (2019). In the experiment, a participant was asked to draw a conditionally independent private signal and predict which of two equally-likely events had happened in the presence of known predictions made by prior participants. The events were denoted as *A* box and *B* box, and the signal was either *a* ball or *b* ball. Each of the two boxes (*A*, *B*) contained 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. In a total of 12 experimental rounds, a participant received public information (that is, the box designated but not the ball drawn) presented in an accumulated random order about the decisions made by predecessors.

At the beginning of a round, one of the two boxes was randomly assigned to all participants from which to draw a ball and participants were then asked to predict from which box the ball was drawn. Predictions made by seven predecessors, representing public information, were then shown to the participant sequentially. The seven predecessors were not physically present in the experiment but had made their choices sequentially in a prior session and could observe each other's choices. Note that we do not employ deception in the experiment. Subjects were clearly told that deception was not allowed in experimental economics (Charness et al., 2021). In a pilot experiment, we recruited seven subjects who were randomly assigned as *P1* to *P7*. The seven subjects drew their private signals and made their choices sequentially. We sampled a very large number of choices from the pilot experiment.[4] We chose 12 rounds and use these rounds for Experiment 1. These people agreed that their choices could be used in subsequent sessions. We arranged the seven people in a random order and indexed them as *P1*–*P7*. The participant in the experimental session then acted as *P8* and drew a ball from the box assigned to all the predecessors in the round. The participant was informed that *P1*–*P7* also received their own conditionally independent private signals by drawing a ball from the same box. At the end of each round, *P8* made a prediction about which box the ball was drawn from after observing his own private signal (*a* ball or *b* ball) and the seven predecessors' public information (*A* box or *B* box).

The procedure of a single round is depicted in Fig. 1. Each round presents the predictions or choices made by *P1* to *P7* at the center of the computer screen in sequential order with an interval of five seconds between each pair. After seven predecessors' predictions have been displayed, *P8* presses the "Draw ball" button to receive his or her private signal. Once *P8* receives his or her private signal (*a* or *b*), *P8* has to make a prediction of which box (*A* or *B*) his or her ball (*a* or *b*) will be drawn from.

For each participant, the basic procedure is as follows: The participant is informed that there are two boxes, an *A* box (which contains two *a* balls and one *b* ball) and a *B* box (which contains two *b* balls and one *a* ball). He or she is told that one of the boxes will be chosen at random. The task is to draw a ball from that box and guess which box that ball is drawn from. This ball serves as his or her "private signal". He or she is also told that they will see the guesses of the seven preceding participants whose balls are drawn from the same box. These guesses serve as "public information".

Participant repeats this procedure twelve times (i.e., rounds). That is, the participant completes a total of six rounds in which his or her private signal matches a majority of the seven predecessors' guesses, and six rounds in which his or her private signal goes against the majority of the seven predecessors' guesses. The 12 rounds are presented in a random order.

Following Frydman and Krajbich (2022), we define a variable called the Net Public Information for P_i as $NPI_i = (-1)^{1+1_{a,i}} \times \sum_{N=1}^{i-1}\left(1_{A,N} - 1_{B,N}\right)$, $i \in [1,7]$. The first term $((-1)^{1+1_{a,i}})$ is 1 if P_i receives private signal *a*, and -1 otherwise. The second term $(\sum_{N=1}^{i-1}\left(1_{A,N} - 1_{B,N}\right))$ is the difference between the number of observed "*A*" choices (or box) and "*B*" choices. $NPI_i > 0$ indicates that P_i receives a congruent private signal, which means the private signal matches the majority of the predecessors' guesses; while $NPI_i < 0$ indicates an incongruent private signal, which means the private signal goes against the majority of the predecessors' guesses.

NPI has six different values in Experiment 1, i.e., 1, 3, and 5 in the congruent condition and -1, -3, and -5 in the incongruent condition. For example, if two predecessors have chosen *B* box, the other five predecessors have chosen *A* box, and the participant receives *a* ball, then $NPI = 3$, while $NPI = -3$ if the participant receives *b* ball.

We create a design matrix ($2 \times 3 \times 2 = 12$ rounds) (See Table 1) by using all combinations of conditions (incongruent vs. congruent), absolute *NPI* (the difference between the numbers of "*A*" and "*B*" choices) (5 vs. 3 vs. 1), and *P8*'s ball type (*a* vs. *b*). To reduce errors in the comparison of the tendency to follow 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' the tendency to follow private information outweighs the cost of the manipulation.

[3] Amini et al. (2016) compared the degree of conformity in groups with varying gender compositions. Their experimental data showed little evidence that gender composition affected the expression of minority views. In addition, previous laboratory experiments on male versus female decision making have typically used between 50 and 60 participants (Eckel & Füllbrunn, 2015).

[4] We also conducted two pilot experiments and chose 24 and 8 rounds for the Experiment 2 and Experiment 3, respectively.

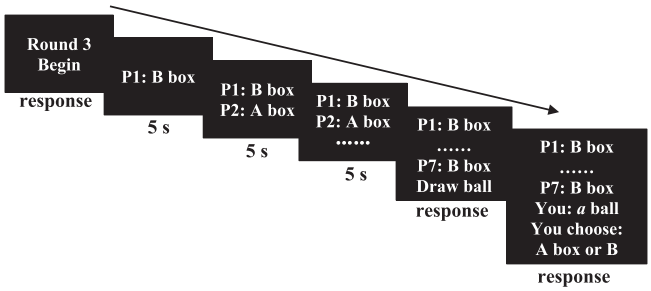

Fig. 1. Time course of a single round. At the beginning of each round, a participant is presented with the current round number followed by choices made by *P1* to *P7*. Once a participant presses the "Begin" button, *P1*'s choice is displayed on the screen. Five seconds later, *P2*'s choice is displayed, and so on. The seven predecessors' choices are displayed sequentially, and the interval between the displays of choices is fixed at 5 s. 35 s after all seven predecessors' choices have been displayed, *P8* draws a ball by pressing the "Draw ball" button. Finally, *P8* makes a choice after observing his or her private signal.

Table 1
Seven predecessors' choices used in Experiment 1.

Condition	Absolute *NPI*	*P1*–*P7*'s choices (box)	*P8*' private signal (ball)
Incongruent ($NPI < 0$)	5	*A-A-B-A-A-A-A*	*b*
		B-B-A-B-B-B-B	*a*
	3	*A-A-B-B-A-A-A*	*b*
		B-B-A-A-B-B-B	*a*
	1	*B-A-B-B-A-A-A*	*b*
		A-B-A-A-B-B-B	*a*
Congruent ($NPI > 0$)	5	*A-A-B-A-A-A-A*	*a*
		B-B-A-B-B-B-B	*b*
	3	*A-A-B-B-A-A-A*	*a*
		B-B-A-A-B-B-B	*b*
	1	*B-A-B-B-A-A-A*	*a*
		A-B-A-A-B-B-B	*b*

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

2.1.3. Bayesian Nash equilibrium (BNE)

As a rational benchmark, we 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 *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

[5] The experimental instructions are available in the Online Appendix.

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. However, participants as *P8* can simply count the numbers of observed "*A*" choices (or boxes) and "*B*" choices to approximate optimal decision making in this situation.[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.[7]

2.2. Results

We perform a mixed-design ANOVA on individual choice with condition, 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 that is equal 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 examined with Bonferroni-Corrected post hoc tests.[8]

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

Importantly, we find that men's proportion of choices in line with the private signal in the incongruent condition ($M = 42.94$ %, $SE = 3.57$ %), is significantly higher than women's ($M = 25.78$ %, $SE = 3.53$ %) ($p = 0.001$, Cohen's $d = 0.66$), but there are no significant gender differences in choices in line with the private signal in the congruent condition ($M_{\text{men}} = 98.11$ %, $SE_{\text{men}} = 1.15$ %; $M_{\text{women}} = 96.47$ %, $SE_{\text{women}} = 1.16$ %; $p = 0.222$, Cohen's $d = 0.19$).

The main effect of absolute *NPI* [$F(1, 103) = 82.47$, $p < 0.001$, $\eta_p^2 = 0.445$] and the interaction effect of condition × absolute *NPI* [$F(1, 103) = 88.01$, $p < 0.001$, $\eta_p^2 = 0.461$] are also significant, but the interaction effects of absolute *NPI* × gender and condition × absolute *NPI* × gender are not significant (all p values >0.50).[9] In the incongruent condition, the proportions of participants' choices in line with their private signal is 20.09 % (SE = 3.09 %) when $NPI = -5$, 21.99 % (SE = 3.21 %) when $NPI = -3$, and 61.02 % (SE = 3.59 %) when $NPI = -1$. This result suggests that in the incongruent condition, as the value of the absolute *NPI* increases, the percentage of participants who choose in line with private information decreases, indicating that the theoretically calculated BNE correlates with the rationality of participants' choices. However, the gender effect is not affected by the *NPI*.

3. Experiment 2

Experiment 1 shows that men are more likely to follow private information than women, and that this gender effect is primarily present in the incongruent condition, where participants' private signals contradict the majority of public information.

One concern is that in Experiment 1, participants are in a fixed position (i.e., the eighth position), and thus whether the gender effect is robust when we change participants' position. Another concern is that in Experiment 1, in the incongruent condition, the public information that is consistent with participants' private signals always comes from the first four predecessors. That is, in the incongruent condition, the last three predecessors' choices were always the same (AAA or BBB), and this public information always contradicts the participants' private signal. It is uncertain whether the gender effect is robust to the order of public information consistent with the private signal in the incongruent condition.

To answer these concerns, in Experiment 2, we change the participants' position to *P7*; we also change the order of (in)consistent public information, i.e., the order of public information consistent with the private signal in the incongruent condition or inconsistent with the private signal in the congruent condition.

[6] Guarino et al. (2011) developed a model of aggregate information cascades where the entire history of individual decisions was not observed. In this model, participants were not aware of their own position in the sequence and were only informed about the total number of others who had chosen the observable choice before them. The authors argued 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.

[7] In Experiment 1, a participant can update his or her beliefs after receiving a private signal, which corresponds 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.

[8] All reported p-values are two-tailed and are corrected for multiple comparisons.

[9] In Experiment 1, the main effect of *P8*'s ball type is significant [$F(1,103) = 8.64$, $p = 0.004$, $\eta_p^2 = 0.077$], but the interaction effect of condition × *P8*'s ball type × gender is not significant ($p = 0.885$). This result indicates that the gender effect is not affected by the ball type.

3.1. Method

3.1.1. Participants

A total of 47 undergraduate students (23 male, 24 female) from Nankai University were recruited to participate in Experiment 2 via flyers and emails. Participants' ages ranged from 19 to 27 years ($M = 21.72$; $SD = 2.32$). The average payoff was about 44 Chinese yuan. The sample size was chosen to have at least 80 % statistical power to replicate the results of Experiment 1 at a 5 % significance level.[10] This experiment was approved by the ethical board of the university. Experiment 2 was a laboratory experiment and was conducted in June 2019.

3.1.2. Design

In Experiment 2, 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 *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 *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 *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 *P1* to *P6*'s choices (box) are *A-A-A-A-A-B*, then the order of inconsistent public information is in the posterior.

By using all combinations of condition, absolute *NPI*, order of (in)consistent public information, and *P7*'s private signal, a design matrix ($2 \times 2 \times 3 \times 2 = 24$ rounds, see Table 2) is created. Therefore, a total of 24 rounds are included in Experiment 2. All other aspects of the experimental design and procedure are identical to Experiment 1.

3.2. Results

A mixed-design ANOVA of individual choice with condition, absolute *NPI*, order of (in)consistent public information, and *P7*'s ball type as within-subject factors and gender as a between-subject factor is performed. In line with Experiment 1, significant main effects 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 × gender [$F(1, 45) = 4.92$, $p = 0.032$, $\eta_p^2 = 0.098$] are found. Post hoc tests show that men make a significantly higher proportion of decisions consistent with the private signal than women ($M_{\text{men}} = 64.31$ %, $SE_{men} = 2.70$ %; $M_{\text{women}} = 56.25$ %, $SE_{women} = 2.64$ %; $p < 0.01$, Cohen's $d = 0.62$). Specifically, in the incongruent condition, men have a higher fraction of choices consistent with their private signals ($M = 31.88$ %, $SE = 5.82$ %) than women (M = 13.54 %, SE = 5.70 %) ($p < 0.01$, Cohen's $d = 0.65$), but in the congruent condition male and female participants do not differ ($M_{\text{men}} = 96.74$ %, $SE_{men} = 1.64$ %; $M_{\text{women}} = 98.95$ %, $SE_{\text{women}} = 1.60$ %) ($p = 0.338$, Cohen's $d = 0.27$).

As in Experiment 1, we also find that the main effect of absolute *NPI* [$F(1, 45) = 3.28$, $p = 0.077$, $\eta_p^2 = 0.068$] and the interaction effect of condition × absolute *NPI* [$F(1, 45) = 6.25$, $p = 0.016$, $\eta_p^2 = 0.122$] are significant, but the interaction effects of absolute *NPI* × gender and condition × absolute *NPI* × gender are not significant (all p values >0.30). That is, in the incongruent condition, as the value of the absolute *NPI* increases, the percentage of participants who choose in line with private information decreases (*NPI* = −4: $M = 19.67$ %, $SE = 4.10$ %; *NPI* = −2: $M = 25.75$ %, $SE = 4.45$ %), but the gender effect is not affected by the *NPI*.

Moreover, the interaction effect of condition × order of (in)consistent public information is significant [$F(1, 45) = 8.396$, $p = 0.006$, $\eta_p^2 = 0.157$], but the main effect of order of (in)consistent public information and the interaction effects of order of (in)consistent public information × gender, order of (in)consistent public information × absolute *NPI*, and condition × order of (in)consistent public information × gender are not significant (all p values >0.14).[11] In the incongruent condition, the proportions of participants' choices consistent with their private signal are 28.44 % (SE = 4.88 %), 19.27 % (SE = 4.61 %), and 20.42 % (SE = 4.34 %) when the order of consistent public information is in the anterior, middle, and posterior, respectively. This result suggests that in the incongruent condition, participants are more likely to follow their private information when the consistent public information is in the anterior. However, the gender effect is not affected by the order of (in)consistent public information.

Thus, consistent with Experiment 1, we find in Experiment 2 that male participants make a significantly higher proportion of choices consistent with their private signals than female participants, indicating that men are more likely to follow private information than women. This result shows that the gender effect is robust when we change the order of (in)consistent public information and participants' position.

[10] Based on the effect size of Experiment 1 (i.e., condition × gender interaction effect), we ran an a priori power analysis in G*power of ANOVA with repeated measures and within-between interactions. We set effect size $f = 0.3314784$ (partial $\eta^2 = 0.099$), α error probability = 0.05, power (1 − β error probability) = 0.80, number of groups = 2 (male vs. female), number of measurements = 2 (incongruent condition vs. congruent condition), correlations among repeated measures = 0, and nonsphericity correction $\epsilon = 1$. The results suggested a stopping criterion of 38 participants as a reasonable estimate to ensure a statistical power of 0.8 (with an alpha level of 0.05).

[11] In Experiment 2, the main effect of *P7*'s ball type and the interaction effect of condition × *P7*'s ball type × gender are not significant (all p values >0.10).

Table 2
Six predecessors' choices used in Experiment 2.

Condition	Absolute *NPI*	Order of (in)consistent public information	*P1–P6*'s choices (box)	*P7*'s private signal (ball)
Incongruent ($NPI < 0$)	4	Anterior	*A-B-A-A-A-A*	*b*
			B-A-B-B-B-B	*a*
		Middle	*A-A-B-A-A-A*	*b*
			B-B-A-B-B-B	*a*
		Posterior	*A-A-A-A-A-B*	*b*
			B-B-B-B-B-A	*a*
	2	Anterior	*B-B-A-A-A-A*	*b*
			A-A-B-B-B-B	*a*
		Middle	*A-A-B-B-A-A*	*b*
			B-B-A-A-B-B	*a*
		Posterior	*A-A-A-A-B-B*	*b*
			B-B-B-B-A-A	*a*
Congruent ($NPI > 0$)	4	Anterior	*A-B-A-A-A-A*	*a*
			B-A-B-B-B-B	*b*
		Middle	*A-A-B-A-A-A*	*a*
			B-B-A-B-B-B	*b*
		Posterior	*A-A-A-A-A-B*	*a*
			B-B-B-B-B-A	*b*
	2	Anterior	*B-B-A-A-A-A*	*a*
			A-A-B-B-B-B	*b*
		Middle	*A-A-B-B-A-A*	*a*
			B-B-A-A-B-B	*b*
		Posterior	*A-A-A-A-B-B*	*a*
			B-B-B-B-A-A	*b*

4. Experiment 3

Experiments 1 and 2 involve long sequences of decisions, i.e., participants act as *P8* or *P7*. Compared with short sequence of decisions, Goeree et al. (2007) indicated that long sequences of decisions had several features, such as an almost complete absence of pure cascades. In addition, Guarino and Jehiel (2013) showed that participants tended to follow the earlier public information. Thus, one concern is that whether the gender effect is still present in the short sequences of decisions. To address this concern, we conduct Experiment 3 in which several short sequences of decisions are designed. Participants' positions are *P3* and *P5* in Experiment 3.

4.1. Method

4.1.1. Participants

A total of 59 undergraduate students (30 male, 29 female) from Nankai University were recruited via flyers and e-mails to participate in Experiment 3. The sample size was chosen to have at least 80 % statistical power to replicate the results of Experiment 1 at the 5 % significance level. Participants' ages ranged from 19 to 27 years ($M = 21.71$; $SD = 1.58$). The average payoff was about 23 Chinese yuan. This experiment was approved by the ethical board of the university. Experiment 3 was a laboratory experiment and was conducted in October 2019.

4.1.2. Design

In Experiment 3, a design matrix ($2 \times 2 \times 2 = 8$ rounds, see Table 3) is created by using combinations of condition ($NPI = -2$ vs. $NPI = 2$), position (*P3* vs. *P5*), and private signal (*a* vs. *b*). All other aspects of the experimental design and procedure are identical to Experiment 1.

4.2. Results

A mixed-design ANOVA of individual choice with condition, position, and ball type as within-subject factors and gender as a between-subject factor is performed. We find significant main effects of condition [$F(1, 57) = 305.39$, $p < 0.001$, $\eta_p^2 = 0.843$] and gender [$F(1, 57) = 5.436$, $p = 0.023$, $\eta_p^2 = 0.087$], as well as an interaction effect of condition × gender [$F(1, 57) = 5.704$, $p = 0.020$, $\eta_p^2 = 0.091$]. That is, men have a significantly higher fraction of choosing in line with their private signal than women ($M_{\text{men}} = 65.83$ %, $SE_{men} = 2.69$ %; $M_{\text{women}} = 56.90$ %, $SE_{\text{women}} = 2.73$ %; $p = 0.023$, Cohen's $d = 0.61$). Specifically, in the incongruent condition, male participants show a higher proportion of choices consistent with their private signals ($M = 38.33$ %, $SE = 4.82$ %) than the female participants ($M = 20.69$ %, $SE = 4.90$ %) ($p = 0.013$, Cohen's $d = 0.67$). However, the proportions of choices in line with the private signals do not differ between genders in the congruent condition ($M_{\text{men}} = 93.733$ %, $SE_{\text{men}} = 2.06$ %; $M_{\text{women}} = 93.10$ %, $SE_{\text{women}} =$

Table 3
Predecessors' choices used in Experiment 3.

Condition	Predecessors' choices (box)	Private signal (ball)
$NPI = -2$	*A-A*	*b*
	B-B	*a*
	A-B-B-B	*a*
	B-A-A-A	*b*
$NPI = 2$	*A-A*	*a*
	B-B	*b*
	A-B-B-B	*b*
	B-A-A-A	*a*

2.10 %) ($p = 0.938$, Cohen's $d = 0.01$).

The main effect of position and the interaction effects of position × gender and condition × position × gender are not significant (all p values >0.15).[12] That is, in the incongruent rounds, the gender effect is present regardless of whether participants are in the third or fifth position (third position: $M_{\text{men}} = 36.67$ %, $SE_{\text{men}} = 5.50$ %; $M_{\text{women}} = 18.96$ %, $SE_{\text{women}} = 5.59$ %; fifth position: $M_{\text{men}} = 40.00$ %, $SE_{\text{men}} = 7.05$ %; $M_{\text{women}} = 22.41$ %, $SE_{\text{women}} = 7.17$ %) (all p values <0.01). This result suggests that the gender effect is not affected by the length of the predecessor's public information or the subject's position.

In line with Experiments 1 and 2, Experiment 3 shows that in the incongruent condition male participants are more likely to follow private information than female participants; this gender effect is not present in the congruent condition. These results suggest that gender differences in the tendency to follow private information are robustly present in short decision sequences.

5. Experiment 4

Experiments 1, 2, and 3 show that the gender differences in the tendency to follow private information are robustly present when we change the order of (in)consistent public information and participants' position; the results are also robust to the long and short sequences of decisions. However, in Experiments 1, 2, and 3, the predecessors are not physically present in the experimental session but have made their choices sequentially in a previous session, and the participants are students. One concern is whether our results are robust when the predecessors were physically present in the experimental session and when the participants were not students. To address this concern, we conduct Experiment 4 in which the predecessors are present in the experimental session and the participants are general people. In Experiment 4, we also measure overconfidence to test whether overconfidence is a mechanism underlying the gender effect.

5.1. Method

5.1.1. Participants

A total of 447 nonstudent subjects (218 male, 229 female) were invited to participate in Experiment 4. The sample size was chosen to have at least 80 % statistical power to replicate the results of Experiment 1 at the 5 % significance level. Participants' ages ranged from 24 to 43 years ($M = 32.53$; $SD = 2.72$). The subjects were recruited via Wechat and received a link of the experiment webpage to the WeChat and finished Experiment 4.[13] They came from Tianjin, China, and worked in a broad range of industries, such as banking, manufacturing and IT. Due to budget constraints, every twentieth subject was randomly chosen for actual payment at the end of the experiment. This was common knowledge among subjects. The average payoff was about 84 Chinese yuan. This experiment was approved by the ethical board of the university. Experiment 4 was an online experiment and was conducted in September 2020.

5.1.2. Design

At the beginning of the experiment, each participant was randomly assigned as *P1*, *P2*, or *P3*. That is, 149 participants (70 male, 79 female) were assigned as *P1*, 149 participants (77 male, 72 female) were assigned as *P2*, and 149 participants (71 male, 78 female) were assigned as *P3*. The participant's position was not changed during the entire experiment.

Experiment 4 consisted of 10 rounds. In each round, three participants indexed as *P1*, *P2*, and *P3* were randomly paired as a group. In each round the members of a group would be changed. Participants did not know who they were paired with and had no information about the gender of their group members.

Each round the decision task was the same with Experiment 1. At the beginning of each round, one of the boxes (*A* or *B*) is randomly chosen with equal probability (i.e., 0.5). The first person (*P1*) draws one ball (*a* or *b*) from the selected box. *P1* then makes a choice, which would be shown to every member of the group. Afterwards, the second person (*P2*) draws his or her private signal, and in addition, *P1*'s choice is shown again. As before, *P2* has to decide between *A* and *B* box, followed by feedback to every group member. At

[12] In Experiment 3, the main effect of ball type and the interaction effect of condition × ball type × gender are not significant (all p values >0.50).
[13] The link of experiment webpage is generated via a professional survey platform called "Wenjuanxing", which provides functions equivalent to Qualtrics survey platform.

the end of each round, *P3* makes a prediction about which box the ball is drawn from after observing his or her own private signal (*a* ball or *b* ball) and the two predecessors' public information (*A* box or *B* box). Participants' decisions had no time limit. Immediately after the experimental task, we asked participants how confident they were in their decisions (1 = not at all confident, 7 = very confident). We used this survey question as a measure of overconfidence.

At the end of the experiment, the true states in all 10 rounds are revealed and those who predicted correctly receive 15 Chinese yuan for each round, and 0 Chinese yuan otherwise.

5.2. Results

As shown in the section of Bayesian Nash Equilibrium (BNE), both *P1* and *P2* would reveal his private signal as public information. If *P3* observes both *P1* and *P2* choosing the same box (e.g., *A* box), and *P3* receives a *b* ball, it is rational for *P3* to choose *A* box regardless of his own private signal (i.e., *b* ball). However, if *P3* tends to follow private information, *P3* will follow his or her own private signal (i.e., *b* ball) and choose *B* box. Thus, we mainly analyze *P3*'s actions.

We find that the gender differences in the tendency to follow private information are robust when the predecessors are present in the experiment and when the participants are not students. On average, male and female *P3*'s fraction of choosing in line with private information is 78.45 % ($SE = 1.13$ %) and 75.64 % ($SE = 1.24$ %), respectively; this difference is significant ($p = 0.097$, Cohen's $d = 0.27$).

Table 4 shows *P3*'s fraction of choosing in line with private signal *NPI* and gender. Importantly, we find that there are significant gender differences in the tendency to follow private information when *P3* observes both *P1* and *P2* choosing the same box but *P3* receives a private signal against *P1*'s and *P2*'s choices (i.e., $NPI = -2$). Specifically, when *P3* observes both *P1* and *P2* choosing *A* box and *P3* receives a *b* ball, male participants have a higher proportion of choices consistent with their private signals ($M = 32.62$ %, $SE = 4.06$ %) than the female participants ($M = 14.47$ %, $SE = 5.34$ %) ($p = 0.007$, Cohen's $d = 0.45$). This result also holds when *P3* observes both *P1* and *P2* choosing *B* box and *P3* receives a *a* ball ($M_{\text{men}} = 39.71$ %, $SE_{\text{men}} = 4.60$ %; $M_{\text{women}} = 20.51$ %, $SE_{\text{women}} = 5.79$ %) ($p = 0.010$, Cohen's $d = 0.43$). However, no significant gender differences in the tendency to follow private information are found in other situations (i.e., $NPI = 2$ and $NPI = 0$).

We also find that male *P3* reports a significantly higher level of confidence on their decisions than female *P3* ($M_{\text{men}} = 5.197$, $SE_{\text{men}} = 0.208$; $M_{\text{women}} = 4.423$, $SE_{\text{women}} = 0.153$; $t\,(147) = -3.031$, $p = 0.003$, Cohen's $d = 0.49$). Participants' level of overconfidence is positively correlated with the proportion of choices in line with the private signal (Spearman's rho = 0.396, $p = 0.002$), i.e., participants with a higher level of overconfidence are more likely to follow private information.

We then 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 5000 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 = 0.062, 95 % CI: 0.021 to 0.112). These results indicate that overconfidence is a mechanism underlying the gender differences in the proportion of choices in line with the private signal.

6. Experiment 5

In the previous four experiments, the predecessors' choices are presented cumulatively, i.e., participants observe the predecessors' choices sequentially before receiving private signals. It is an open question whether gender differences in the tendency to follow private information are robust when predecessors' choices are presented directly to the experimental participants.[14] To answer this question, we conduct Experiment 5, in which we directly present the predecessors' choices to the experimental participants.

6.1. Method

6.1.1. Participants

A total of 61 undergraduate students (30 male, 31 female) from Nanjing University of Finance & Economics were recruited via flyers to participate in Experiment 5. The sample size was chosen to have at least 80 % statistical power to replicate the results of Experiment 1 at the 5 % significance level. Participants' ages ranged from 20 to 25 years ($M = 22.43$; $SD = 1.38$). The subjects received a link of the experiment webpage to the WeChat and finished Experiment 5. The average payoff was about 14 Chinese yuan. This experiment was approved by the ethical board of the university. Experiment 5 was an online experiment and was carried out at the beginning of November 2024.

6.1.2. Design

The experimental design and procedure for Experiment 5 are closely followed Experiment 1, except that in Experiment 5 the seven predecessors' choices are presented directly to the experimental participants (i.e., *P8*). At the end of the experiment, the true states in all 12 rounds are revealed and those who predicted correctly receive 2 Chinese yuan for each round, and 0 Chinese yuan otherwise. To provide further evidence for the mechanism, we also measure overconfidence after the experimental task, as in Experiment 4.

[14] We thank an anonymous reviewer for pointing this out.

Table 4
P3's fraction of choosing in line with private signal by *NPI* and gender.

NPI	*P1*'s and *P2*'s choices (box)	*P3*'s private signal (ball)	*P3*'s fraction of choosing in line with private signal	
			Male ($N = 71$)	Female ($N = 78$)
−2	*A-A*	*b*	32.62 %	14.47 %
	B-B	*a*	39.71 %	20.51 %
2	*A-A*	*a*	96.29 %	97.69 %
	B-B	*b*	97.53 %	96.92 %
0	*A-B*	*a*	98.76 %	97.69 %
	A-B	*b*	96.29 %	95.38 %
	B-A	*a*	95.37 %	93.84 %
	B-A	*b*	96.29 %	98.46 %

6.2. Results

We find that the results of Experiment 5 are remarkably similar to those of Experiment 1. The mixed-design ANOVA shows significant main effects of condition [$F(1, 59) = 324.02$, $p < 0.001$, $\eta_p^2 = 0.846$] and gender [$F(1, 59) = 10.84$, $p = 0.002$, $\eta_p^2 = 0.155$], as well as a significant condition × gender interaction effect [$F(1, 59) = 10.35$, $p < 0.001$, $\eta_p^2 = 0.149$]. Post hoc tests indicate that men have a significantly higher proportion of choices in line with the private signal than women ($M_{\text{men}} = 70.28$ %, $SE_{\text{men}} = 1.94$ %; $M_{\text{women}} = 61.29$ %, $SE_{\text{women}} = 1.91$ %; $p = 0.002$, Cohen's $d = 0.84$). Importantly, men's proportion of choices in line with the private signal in the incongruent condition ($M = 45.55$ %, $SE = 4.07$ %), is significantly higher than women's ($M = 25.81$ %, $SE = 4.00$ %) ($p < 0.001$, Cohen's $d = 1.53$), but there are no significant gender differences in choices in line with the private signal in the congruent condition ($M_{\text{men}} = 95.00$ %, $SE_{\text{men}} = 1.54$ %; $M_{\text{women}} = 96.77$ %, $SE_{\text{women}} = 1.51$ %; $p = 0.375$, Cohen's $d = 0.21$).

As in Experiments 1 and 2, the main effect of absolute *NPI* [$F(1, 59) = 46.40$, $p < 0.001$, $\eta_p^2 = 0.440$] and the interaction effect of condition × absolute *NPI* [$F(1, 59) = 34.48$, $p < 0.001$, $\eta_p^2 = 0.369$] are significant, but the interaction effects of absolute *NPI* × gender and condition × absolute *NPI* × gender are not significant (all p values >0.80).[15] That is, in the incongruent condition, as the value of the absolute *NPI* increases, the percentage of participants who choose in line with private information decreases, but the gender effect is not affected by the *NPI*.

As in Experiment 4, we find that men report a significantly higher level of confidence on their decisions than women ($M_{\text{men}} = 4.500$, $SE_{\text{men}} = 0.287$; $M_{\text{women}} = 3.613$, $SE_{\text{women}} = 0.281$; $t(59) = -2.211$, $p = 0.031$, Cohen's $d = 0.57$). Participants' level of overconfidence positively correlates with the proportion of choices in line with the private signal (Spearman's rho = 0.598 $p < 0.001$), i.e., participants with a higher level of overconfidence are more likely to follow their own private information. Using the same method of mediation analysis as in Experiment 4, we also find that overconfidence has a significant indirect effect (indirect effect = 0.035, 95 % CI: 0.006 to 0.076). These results provide further evidence that overconfidence is a mechanism underlying the gender effect.

7. Discussion

This paper reports data from a social learning game to investigate gender differences in the tendency to follow private information. Five experiments provide convergent evidence that men are more likely to follow their own private information than women.[16] Specifically, male participants show a significantly higher proportion of choices in line with private information than that of female participants. This result is primarily driven by the fact that men are more likely to follow private signals than women in the incongruent rounds where participants receive a private signal contrary to the majority of the public information. No significant gender effect is found in the congruent rounds where participants receive a private signal that matches the majority of public information. This may reflect a ceiling effect, as the number of choices consistent with private signals in the congruent rounds was very high.

Our findings are robustly present when we vary the order of public information consistent (or inconsistent) with private information and when we change participants' position. The gender effect is robust to the short sequences of decisions and is robust when the predecessors are physically present in the experimental session. The gender effect is also robustly present regardless of whether the predecessors' choices are presented sequentially or directly to the experimental participants. We also show that the gender effect is robustly present among the students and the general people.

We then test a mechanism for the gender effect by collecting post-experiment questionnaires. We find that the propensity to choose in line with private information is positively correlated with overconfidence. Men are more overconfident than women. Overconfidence is a mechanism underlying the gender effect. We note that we provide only suggestive but not conclusive evidence for the mechanism because our measure of overconfidence is a self-reported questionnaire, which is not incentivized.

Apart from overconfidence, an alternative explanation for the gender differences in the tendency to follow private information may be loss aversion. Anderson and Holt (1997) suggested that one of the explanations for herding behavior is that people are averse to

[15] In Experiment 5, the main effect of ball type and the interaction effect of condition × ball type × gender are not significant (all p values >0.60).
[16] In the incongruent condition across different experimental setups, the proportion of men choosing in line with private signals ranges from 31 % to 46 %; in contrast, the proportion of women choosing in line with private signals ranges from 13 % to 26 %. In the congruent condition across experimental setups, the proportion choosing in line with private signals is all above 93 %, and this result holds for both men and women.

standing alone. Subjects might prefer the chance of being wrong with everybody else to the risk of providing a deviant prediction that turned out to be the only incorrect one. There is evidence that women are more loss averse than men (Bouchouicha et al., 2019). Thus, women may be more likely to follow the public information of others because they are averse to standing alone. We encourage further research to test the role of loss aversion in gender differences in the tendency to follow private information.

Our findings have important practical implications. There are widespread gender imbalances in business and finance environments. Thus, a better understanding of the gender differences in the tendency to follow private information has important implications for the design of decision-making processes in business, finance, and other economic settings. For example, our experimental results suggest that women investors in financial markets may be better able to infer the right information from the actions of other investors than men investors, indicating it is beneficial to encourage women investors to participate in financial markets. Recently, this argument is supported by several experimental studies. It is beneficial for stock price stability with the participation of women in financial market, such as, female-only market has lower price bubbles than male-only market (Eckel & Füllbrunn, 2015) and mixed-gender composition can reduce mispricing across different types of asset markets (Cueva & Rustichini, 2015).

Ethical statements

Subjects participated in our experiments were given informed consent. Our study is approved by the ethics committee of Nankai University and Nanjing University of Finance & Economics University.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chieco.2025.102350.

Data availability

The data is available on request.

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