Competitor Ability, Sorting and Overconfidence: An Experiment

Tianyi Li* and Charles N. Noussair†

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Abstract

While overconfidence in one's ability relative to others is common, the feeling that one is less qualified than one's peers is widespread in elite groups. In this paper, we show that both effects simultaneously exist for the same individuals and we propose the notion of a *sorting bias* to capture the overall pattern. We conduct an experiment in which individuals first take a mathematics test. They are then sorted into levels based on their performance, and matched with a competitor who scored at a similar level. The matched pairs then take a second mathematics test. Before the sorting into levels, they are asked to predict the probability that they perform better than the person that they are paired with, in a strategy method protocol. If they properly condition on the rule that sorts participants into pairs, they would predict a probability of .5 of being the better performer in their pair. We find that participants act as if they condition on the way their opponent has been sorted but do not sufficiently account for their own sorting. Individuals are less optimistic about outperforming a similarly selected peer, the higher performing the group to which they are assigned. This effect co-exists with a general pattern of overplacement, measured here as a belief that one has a greater than 50% chance of outperforming a peer with similar qualifications.

*Department of Economics, University of Arizona, Tucson, AZ 85721, USA.

†Department of Economics, University of Arizona, Tucson, AZ 85721, USA. Email: cnoussair@arizona.edu.

1 Introduction

Overconfidence is a tendency for individuals to overestimate their own abilities and the accuracy of their beliefs and judgments. Overconfidence has been documented in experiments in various domains, such as investment tasks (Barber and Odean (2001), Dittrich et al. (2005)), forecasting (Clark and Friesen (2009), Camerer and Lovallo (1999)), and strategic interactions (Yin et al. (2019)). Field evidence (Johnson and Fowler (2011), Svenson (1981), Weinstein (1980)) also yields the conclusion that overconfidence is widespread and prevalent in many domains and populations, such as CEOs' decision-making, the behavior of drivers, and student academic performance. Moore and Healy (2008) distinguish between three types of overconfidence: overestimation of one's actual performance, overplacement of one's performance relative to others, and excessive precision in one's beliefs (see also Moore and Schatz (2017)). Overplacement is a belief that one ranks higher relative to others than is actually the case. Overplacement is our focus in this paper.

At the same time, the feeling that one is not as qualified as one's peers is very widespread in elite groups.[1] Consider, for example, a graduate student in a top-ranked program. Impressed by the ability of other students, she believes herself to be less capable than the others in her class and thus that she does not belong in the program.[2] These two effects, a general tendency toward overplacement coupled with underplacement among those of high ability, have been reconciled by considering those of high and low ability separately. Kruger and Dunning (1999) have shown that individuals of low ability tend to overplace themselves relative to others. Their own and later work has also found that those of high ability also have some tendency toward underplacement (Schlösser et al. (2013).)

We consider whether both effects can be explained by a common specific decision

[1] Indeed, the phenomenon of imposter syndrome, in which individuals doubt their abilities and fear being exposed as frauds (Clance and Imes (1978)), has gained much attention in psychology. This bias in belief appears to affect individuals in many professions and can be accompanied by anxiety, depression, self-doubt, and stress. It hits individuals of all genders and ethnicities that have been studied (Kolligian Jr and Sternberg (1991), Clance and OToole (1987), Gottlieb et al. (2020), Hutchins (2015), Cokley et al. (2017), Bernard et al. (2018)). One component of the syndrome appears to be underconfidence when one is in a high performing group. This underconfidence can arise as part of a sorting bias.

[2] The KPMG Women's Leadership Summit reported in 2020 that a shocking 57% of female executives felt like an imposter when they assumed a new leadership role or became an executive. Studies have shown that imposter syndrome affects 22-60% of medical students (Ng and Tay (2021), Gottlieb et al. (2020)), university faculty members (Brems et al. (1994), Hutchins (2015)), and is particularly widespread among members of minority groups (Bernard et al. (2018), Cokley et al. (2017)).

bias, rather than distinct biases held by high and low ability individuals. That is, we study whether there is a single bias held by individuals of all abilities. We propose that there is a failure to condition properly on a selection process one has undergone. One takes into account that other individuals have undergone a sorting process, but fails to properly account for one's own selection. We refer to this as a *sorting bias*. This is a bias that is distinct from overconfidence.

The purpose of the study we report here is to establish whether beliefs about relative performance exhibit a sorting bias. In our graduate student example described above, the individual correctly acknowledges that the other students in the competitive program are very capable, and understands that they have successfully met very exacting standards of admission to the top program. However, she does not adjust her expectations about relative performance to the fact that she herself has also satisfied the same admission criteria. Therefore, instead of believing that she would be an average performer among a group that has been subject to the same selection that she was, she believes that she is below average. This type of bias suggests that the more selective the criteria for admission are, the lower one's own expectations of one's own performance relative to others would be. Thus, a student attending a higher-ranked program would believe that their ranking within the program would be relatively low, while a student attending a less competitive program might believe that their ranking would be higher than their median. This second student would place too little weight on the fact that the less competitive program was the best one that they could gain admission to themselves, which is crucial information for gauging one's ability.

In the laboratory experiment we report here, eight participants complete a mathematics test. They are assigned into four pairs based on their performance on the test, with the top two performers in one pair, the next two in another pair, etc... They then proceed to take another similar test and compete with their counterpart, who is assigned to the same pair and thus had a similar performance to their own. After the first test, but before participants learn about their performance in the test or the pair to which they have been assigned, they perform a prediction task. They make incentivized predictions about the probability that they would outperform their counterpart in the second math test, conditional on their being assigned to each of the four pairs. This strategy method protocol allows us to directly observe how individuals' predictions vary depending on the pair that they have been assigned to. If individuals condition appropriately on the fact that they have been assigned to a pair with another person exhibiting similar performance, they would estimate their probability of winning on the second test at .5. If they are overconfident and overplace themselves, they would submit probabilities greater than .5. If they fail to fully account for their own assignment to a group, they would assign a lower probability of winning conditional on assignment into higher-ranked pairs, putting insufficient weight on their own earlier performance. Thus, our experiment allows us to observe, within-subject, a tendency toward underplacement when assigned to a high performance group, along with a tendency toward overplacement in lower-performing groups. The within-subject aspect of our design also allows us to control for idiosynchratic differences among individuals, such as personality traits, that might affect their general level of confidence.

An inevitable feature of a within-subject design is that it emphasizes the contrast between the different decisions to the participants. In our view, this feature is an advantage. It forces an individual to think about the relationship between the groups and makes it clear how they view these relationships. If a participant believes that her probability of outperforming her opponent is independent of the group that she finds herself in, she can clearly indicate that relationship. On the other hand, if she believes that the lower-ranked the group she has been assigned to, the greater her chances of outperfoming her opponent, she can clearly indicate this with our protocol.

We find that a significant majority of the sample exhibits a sorting bias. They have less confidence that they will score better than their opponent, the higher-performing the pair to which they have been assigned. Nevertheless, there remains a strong tendency for individuals to be overconfident. There is diminishing overconfidence in higher-performing pairs. Thus, overconfidence and the sorting bias, two distinct biases, can coexist, within a single individual. Women are slightly less confident than men, though the difference is not significant. Women and men are equally susceptible to the sorting bias.

2 Related Work

The most closely related prior work is a literature that examines the relationship between ability level and the extent of over-and under-placement. Kruger and Dunning (1999), who asked students to estimate their ability and performance in four different tasks, report that overplacement is concentrated among relatively low ability individuals, with high performers having a modest tendency toward underplacement. Tirso et al. (2019) asked students to estimate their grade, rank, and class average score on a midterm exam. After learning the mean score, high performers were found to have lower expectations of both themselves and their peers, with lower class average predictions compared to low performers. High performers predicted that their rank in the class would be below the 50th percentile, suggesting that high performers exhibit underconfidence.

Friehe and Pannenberg (2019), using data from the German Socioeconomic panel, studied the age profile of overplacement with regard to their own income relative to others in the population. They found that overplacement was more severe as individuals get older, with the probability of overplacement increasing from 0.2 at age 18 to 0.6 by one's 50s. They also observed that individuals in the top of the wage distribution tended to underplace themselves while those in the bottom tended to overplace.

The tendency for those at the bottom of the ability distribution to overplace themselves has been interpreted as a consequence of a lack of sophistication. Kruger and Dunning (1999) describe this effect as a double curse: low ability in the task and incorrect beliefs about one's placement, both caused by low sophistication. Krajc and Ortmann (2008) instead argue that in some situations the pattern is evidence of a more difficult signal extraction problem for those of low ability compared to that faced by high-ability individuals. Their argument rests on the structure of the distribution of performance among the subject pools studied and the bounds on the space of beliefs. Schlösser et al. (2013) conduct three experiments and report that they yield empirical patterns more in line with a Dunning-Kruger effect than the relationships predicted by Krajc and Ortmann (2008). None of this literature studies the simultaneous existence of over-and under-placement within the same individual.

In our study, we require individuals to estimate their ability conditional on it being determined that they are strong or weak at a task. Thus, our within-subject comparison allows us to determine whether overplacement occurs when an individual believes she has low ability and underplacement when she believes she has high ability, for the same individual. This would mean that the Dunning-Kruger pattern of over-and under-placement exists independently of actual differences in ability. Whether an given individual over-or under-places themselves depends on their actual placement rather than their ability level.

3 Experimental Design

The computerized experiment was programmed using z-Tree (Fischbacher (2007)) and conducted in 15 in-person sessions at the Economic Science Laboratory at the University of Arizona between February and October of 2022. The 118 undergraduate student participants were recruited from the Economic Science Laboratory's Recruiting Site[3]. 58 of the participants were female and 60 were male. Each session lasted less than one hour. In each session, participants earned a payoff in terms of "points" and each point was converted to US$0.10 at the end of the session. Each session consisted of two parts. The timing of events is illustrated in Figure 1.

In Part 1, all participants were given a mathematics test, which consisted of 10 multiple-choice questions. Among these 10 math questions, 5 were drawn from old SAT (Scholastic Achievement Tests) tests and the other 5 from old GRE (Graduate Record Exam) examinations. Drawing from these two tests rather than one helps to increase the spread in the distribution of scores because the GRE questions are more difficult than the SAT questions and undergraduate students have differing math backgrounds. Having a larger spread in scores reduces the incidence of ties among participants and eases the process of pair matching in Part 2. Participants had 15 minutes to solve as many questions as possible. The remaining time was displayed on participants' screens at all times. They could change their answers before they submitted the test. They received a piece-rate payment of $0.50 for every question solved correctly. The number of questions answered correctly is their score on the test. They did not know their exact payment until the end of the session. Participants were not informed at any time about their performance or the performance of others.

In Part 2, a guessing task and another math test followed the reading of instructions for Part 2. After the math test in Part 1, the instructions for Part 2 introduced and explained the rule of assignment to subject pairs. The eight participants in each

[3]In two of the sessions, fewer than eight individuals were present. In each of these sessions, one graduate student also participated to fill out the session. The two graduate students are not included in the data set that we analyze, because their background and training differ from the rest of the participants. Since there was no feedback in the experiment before the end of the session and participants were unaware of the presence of these additional individuals, the data from other participants were not affected. We therefore include the data from the undergraduate participants in these sessions in the analysis. Including the graduate students does not constitute deception. The graduate students were not confederates in any sense since they were not aware of the purpose of the experiment and were incentivized in the same manner as the other participants. Moreover, subjects were not informed of the academic level of the other participants, so that there was no explicit indication in any session that the other participants were necessarily also undergraduates.

session were assigned into four pairs, according to their performance in Part 1. The two participants having the highest and the second-highest performance were assigned to Pair 1, the two participants with the third and the fourth-highest performance were assigned to Pair 2, and so on. If participants were tied, the tie was broken by randomly assigning tied players to the pair that was immediately higher or lower. For example, suppose that three participants are all tied for third place. Then two of them would be assigned to Pair 2, and one would be assigned to Pair 3. Participants learned how they would be assigned into pairs but did not learn their performance in the math test or the pair that they were in until later on. Within their pair, participants also did not know who was the better or the worse performer between the two.

In the guessing task, before learning their actual pair assignment, participants were asked to predict the chance that they would outperform their opponent in Part 2. Part 2 was another math test with the same incentives as the first test. In this prediction stage, participants received a payoff between 0 to 10 points (\$0 - \$1) based on the accuracy of their predictions. We employed the strategy method and asked participants to consider all four potential scenarios (each of the four pairs that they could be assigned to) and to make guesses for each pair before they knew which pair that they were assigned to. One of these four predictions determined their payoff.

To elicit these predictions, participants were required to complete four statements of the following type: "Suppose you are in Pair 1, you guess __% as the chance that you will outperform your opponent in the next math test." Each question reminds participants that, in each pair, they are facing an opponent with a similar performance to themselves. This strategy method incentivizes each of the participants' four guesses because participants do not know which scenario reflects their actual performance in Part 1. They only find out their actual pair assignment after the prediction task.

The quadratic scoring rule (QSR) was used to incentivize the predictions. Specifically, participants received payoffs depending on their predictions $p \in [0, 1]$, their own performance s_i in the second math test, and their opponent's performance s_{-i} in the second math test. Their payoff π was equal to

$$\pi = \begin{cases} 10 - 10 \times (1-p)^2, \text{if } s_i > s_{-i} \\ 10 - 10 \times p^2, \text{if } s_{-i} > s_i \end{cases}$$

Thus, the payoff depends on both performance and predictions. If two participants are tied, the tie is broken by randomly assigning one of the tied players as a winner and she is considered to have outperformed her opponent. The QSR is incentive compatible.

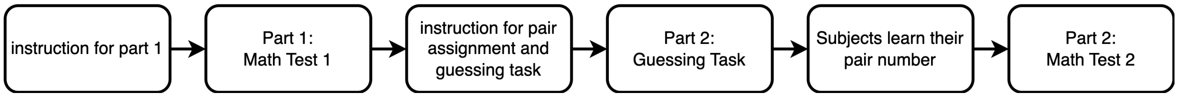

Figure 1: Timeline of Events in the Experimental Sessions

Notes: The sequence of events in a session was the following. The instructions for Part 1 were read. The math test that constituted Part 1 was then administered for 15 minutes. Then the instructions for Part 2 were read. Participants performed the guessing task. They then learned which pair they were in and took the second math test.

Participants are incentivized to report the probability that they truly believe is correct. Here, the marginal incentive for QSR is always less than the piece-rate on the test. This means that individuals have no incentive to report low guesses and score low merely to achieve more points from prediction accuracy.

After the guessing task, all participants take a second math test, which has the same format and consists of 10 different questions that were drawn from the same source as the first one. There is also a 15-minute time limit in effect for the second task. Participants also received an individual piece-rate payment of \$0.50 for each question solved correctly in Part 2. Participants' final session payments equaled their total earnings from both math tests and the payoff for correct predictions in Part 2. The average earnings were about US\$18.

4 Hypothesis

The decision variable of interest is an individual's prediction of the probability of outperforming the person she is paired with in Part 2 of her session. The assignment of individuals to pairs where the two individuals perform similarly means that it is rational for participant i to have a belief of

$$P_{in}\left(x_i > x_j | i, j \in g_n\right) = 0.5, \forall n \tag{1}$$

where P_{in} is i's predicted probability of outperforming her opponent in the nth best pair, x_i is i's own performance and x_j is the performance of his opponent j in Part 2. g_n is the pair to which participant i and his opponent j are assigned, with $n \in \{1, 2, 3, 4\}$, and g_1 indicating the best performing pair and g_4 the worst. When equation (1) holds, individual i properly accounts for her assignment, as well as the assignment of her competitor j, into pair n.

Consider an individual with sorting bias. This individual conditions their belief on the group that the competitor has been assigned to, but not the group that they have been assigned to themselves. This yields the belief given by:

$$P_{in}\left(x_{in} > x_{jn} | j \in g_n\right) \tag{2}$$

Equation (2) represents an extreme case, where player i does not condition at all on her own selection. However, even a failure to fully account for one's own assignment would still lead to some sorting bias. One's beliefs about one's probability of winning become more pessimistic the more selective the pair one is in. In our experiment, this appears as a lower belief in one's own probability of winning, the greater the ability of one's peers. For example, if one is among the top two performers, one takes into account that the competitor is a top performer, but retains the same belief about one's own performance that one would have had if there was no selection. Similarly, an individual among the bottom two performers takes into account the weakness of the opponent, but does not sufficiently correct for the fact that the individual is also a poor performer herself. This is the Hypothesis of our study.

Hypothesis: $P_{in}\left(x_{in} > x_{jn}\right) < P_{i,n+1}\left(x_{i,n+1} > x_{j,n+1}\right)$ *for* $n = 1, 2, 3$. *That is,* $P_{in}\left(x_{in} > x_{jn}\right)$ *is increasing in* n.

The Hypothesis is compatible with overconfidence, which we define here as a belief that one's probability of outperforming a similarly selected peer is greater than 50%. That is, an individual is overconfident in pair g_n if:

$$P_{in}\left(x_i > x_j | i, j \in g_n\right) > 0.5. \tag{3}$$

Under our Hypothesis, an individual may be either over-or under-confident (or both depending on their group assignment). The hypothesis only asserts that an individual has greater confidence in group $n + 1$ than in group n.

5 Results

5.1 Performance on the Two Tests

In this section, all statistical tests are two-sided unless otherwise indicated. On the first mathematics test, each participant pair (e.g. Pair-1, Pair-2, etc...) correctly answered an average of 7.3, 5.3, 3.7, and 2.6 questions out of 10, respectively. Their scores on the second math test were 4.7, 3.9, 2.9, and 3 on average, respectively. Although we did not intend to change the difficulty of the two tests, they do have different average scores.[4]

Participants who received higher scores on the first test also performed better on the second one, as illustrated in Figure 2. In the figure, Score1 on the x-axis indicates an individual's score on the first math test and Score2 on the y-axis is the score on the second. The scatter plot shows a clear positive correlation. The correlation coefficient between the two scores is 0.55, significant at $p < .001$.

5.2 Tests of Predictions

We find strong support for our Hypothesis. Figure 3 presents the distribution of guesses in all four contingencies. Guess1 refers to predictions made assuming that one is competing in Pair 1, Guess2 indicates the predictions made assuming that one is competing in Pair 2, etc... Contingent on competing with opponents in Pair 1, 43 participants exhibited underconfidence, submitting beliefs less than 50%, while 50 showed overconfidence with predictions greater than 50%. In contrast, in Pair 4, only 24 participants exhibited underconfidence and 84 were overconfident.

Table 1 summarizes average predictions conditional on a variety of criteria. The table shows that overall, the average predicted probability of winning increases monotonically with pair number from 48.9% in Pair 1 to 69.6% in Pair 4. At the individual level, 73 of our 118 participants show this strictly monotonic pattern. This proportion is significantly greater than $\frac{1}{16}$ (one-sided $p < 0.001$ according to a binomial test). 1/16 is the probability that a sequence of four submitted beliefs would be monotonic if they were generated randomly, so that we can convincingly reject the hypothesis that beliefs

[4]There is a gender difference in the average score on the first test, with women scoring an average of 4.28 and men 5.22. This difference is significant at the $p = 0.011$ level according to a pooled variance t-test ($t = 2.59$). On the second test, men score on average 3.93 and women on average 3.32. The gender difference on the second test is also significant ($t = 2.20$, $p = 0.030$).

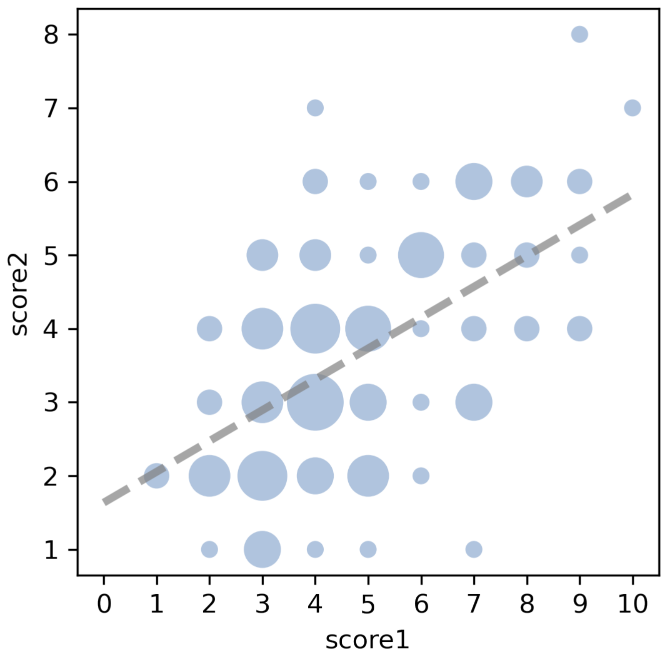

Figure 2: Scatter Plot of Scores in the Two Tests

Notes: Each individual participant is the unit of observation. Horizontal (vertical) axis is score on first (second) test. Diameter of circle is proportional to the number of observations

are unrelated to group assignment.

The data in Table 1 further shows that a monotonic increase occurs among subgroups of participants as well, such as women and men, and for students in each academic year of study. Table 2 also summarizes the number of participants with monotonically increasing, decreasing, constant, and other profiles for those who end up being classified in each of the four pairs, and thus for different ability levels at the task. This table shows that the increasing type is dominant at each ability level, indicating that monotonic beliefs are not specific to high or to low-ability individuals.

The average prediction is significantly greater than 50% for all scenarios other than Pair 1. The mean prediction conditional on assignment to Pair-1 is 48.9%. A two-sided t-test of the hypothesis that the average prediction is less than 50% failed to reject (p = 0.165). Predictions conditional on being in the most selective pair are unbiased.

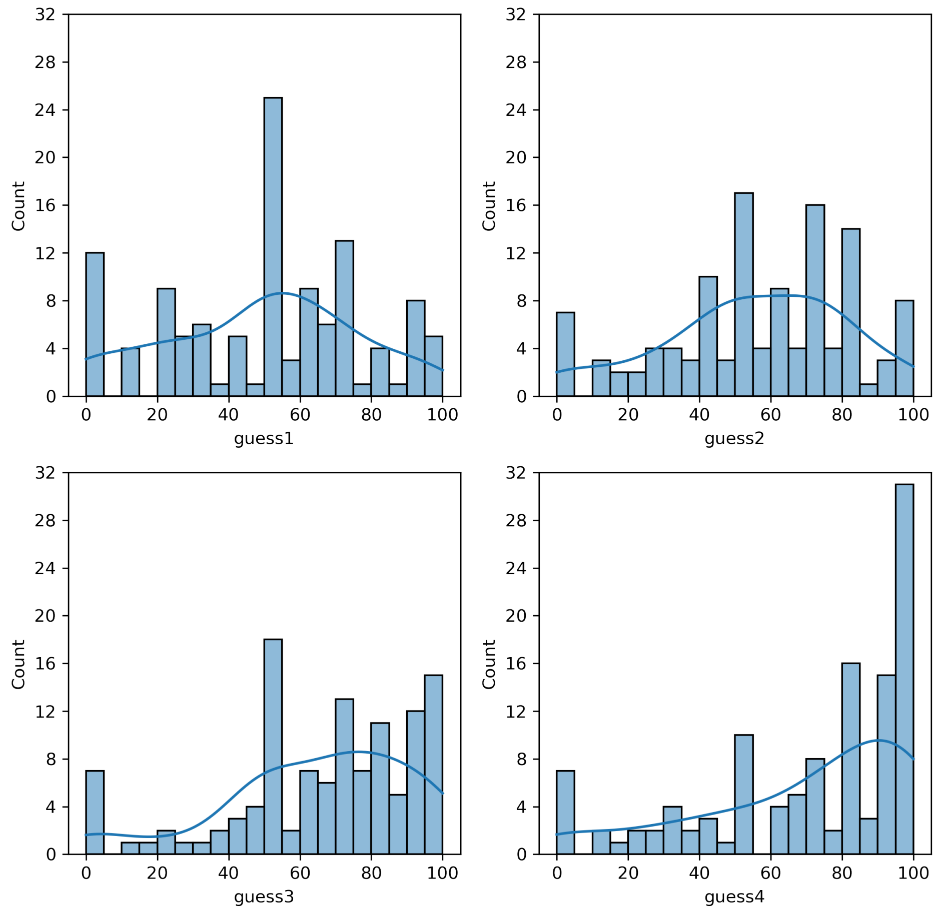

Figure 3: Histogram of Predictions Under the Four Contingencies

Notes: the horizontal axis shows the predictions of the probability that an individual outperforms their competitor on test 2. Bins are ranges of 5%. The vertical axis is the count of individuals that submit predictions within each 5% interval. Guess$_j$ indicates that the prediction is being made contingent on assignment to Pair j.

5.3 Other Results

We now turn to gender differences in predictions. The data show that while men are slightly more confident than women, the differences are modest in magnitude and not significant. For Pairs 1 and 2, men predict a probability of winning of 50.1% and 57.4%,

	Obs	Guess1	Guess2	Guess3	Guess4
Overall	118	48.88%	55.37%	64.71%	69.60%
Gender					
Female	57	47.54%	53.19%	63.14%	68.16%
Male	61	50.13%	57.41%	66.18%	70.95%
Year					
Freshman	34	47.85%	53.71%	61.41%	67.24%
Sophomore	32	53.94%	61.94%	74.56%	77.16%
Junior	32	48.05%	52.25%	59.35%	67.10%
Senior	20	45.44%	52.53%	61.72%	66.13%
Score on Test 1					
10	1	70.00%	80.00%	90.00%	95.00%
9	6	74.33%	76.83%	79.33%	81.00%
8	7	57.14%	64.86%	73.57%	84.86%
7	13	50.00%	61.69%	75.62%	80.69%
6	10	49.10%	56.60%	65.10%	68.10%
5	18	50.28%	53.56%	61.22%	63.61%
4	27	43.93%	57.41%	69.78%	74.04%
3	24	42.88%	46.13%	52.71%	63.92%
2	10	47.60%	45.50%	56.50%	55.00%
1	2	57.50%	47.50%	52.50%	40.00%
Pair Assignment					
1	30	56.67%	64.53%	75.73%	79.70%
2	30	51.00%	55.20%	62.23%	69.30%
3	30	47.93%	55.83%	66.97%	71.87%
4	28	39.29%	45.25%	53.14%	56.68%

Table 1: Average Predictions, Overall and by Gender, Academic Year, Test 1 Score, and Pair Assignment

Notes: The data are the indicated probabilities of outperforming one's competitor, averaged across all participants satisfying the criteria listed in the two left-most columns. The four rightmost columns denote the contingency so that for example "Guess 1" is the submitted predicted probability of outperforming a competitor in the event that one is assigned to Pair 1. Score on first test ranges from 0 to 10 correct answers. Pair Assignment is the actual pair individual is assigned to, with the two highest performing individuals on Test 1 assigned to Pair 1, etc....

respectively. Women give themselves a 47.5% chance to win in Pair 1 and 53.2% in Pair 2. The magnitude of the gender difference is similar in Pairs 3 and 4. On average, men believe that they have a 66.2% chance of winning in Pair 3 and 71% in Pair 4.

Pair	Increasing	Decreasing	Unchanged	Other
Pair 1	23	2	4	1
Pair 2	17	3	8	2
Pair 3	16	3	6	5
Pair 4	17	4	4	3
Total	73	12	22	11

Table 2: Distribution of Trend Types

Notes: The rows indicate the pair to which individual is assigned based on Test 1 performance. The Increasing (Decreasing) profile indicates strictly more (less) confidence as the Test 1 performance of competitor decreases. Unchanged means that there is no relationship between performance of competitor in Test 1 and one's predicted probability of outperforming the competitor in Test 2, that is, one's predicted probability is exactly identical under the four scenarios. The data are the number of individuals satisfying the criterion, with each individual as the unit of observation.

Women are slightly less overconfident: their predictions are 63.1% in Pair 3 and 68.2% in Pair 4. In none of the four pairs is the average belief different for women and men at the 5% level according to a t-test. The incidence of increasing belief profiles was also similar between women and men. 36 of 57 women had an increasing belief profile while 37 of 61 men did so. The difference in proportion is not significant (z = -0.280, p = 0.779, in a two-sided test of proportions).

Participants who exhibited better performance in Test 1 predicted higher winning probabilities than those who performed worse. This can be seen in Table 1. Participants who ended up in Pair 1 believed that they had a 79.7% probability, on average, of outperforming their opponent if they landed in the bottom pair. Those who ended up in Pair 4, with the lowest performance among the group, held a less biased level of confidence, at 56.7%, for Pair 4. On average, those who were assigned to Pair 4 did not exhibit statistically significant overconfidence over all of their guesses. These low performers believed that they had a 48.6% chance of outperforming their opponent, not significantly different from the unbiased prediction of 50%. The fact that better performers are also more overconfident implies that beliefs, at least to some extent, take into account one's own ability, even if they do not properly account for the selection process one has gone through.

6 Discussion

Prior research has shown that overconfidence is prevalent among most people. Nevertheless, many seemingly highly successful people in elite positions have a strong sense that they do not belong there. Our experiment shows that, even within the same individual, conflicting traits of overplacement and underplacement can exist. We have suggested that these phenomena can be generated by a *Sorting Bias*.

The sorting bias is an error in belief formation whereby individuals do properly condition on the selection and sorting that others have gone through but not the sorting that they have been through themselves. For someone in an elite group, this would appear as a recognition that others are highly qualified, but also to a failure to see that one is equally qualified as the others in the group, having undergone the same process of selection. Similarly, an individual in a low-status program or position, if they are subject to a similar bias, would overestimate their likelihood of outperforming a peer in a similar position. Again, they condition their belief on the fact that their competitor has been revealed to be a relatively poor performer, but not on the fact that they have been similarly classified themselves. This bias would lead one to be more overconfident the lower-ranked the group one has been sorted into, the pattern we observe in our data.

We observe that individuals typically believe that they have at least a 50% chance of outperforming their similarly-ranked peer, with the perceived probability usually much higher. The belief contingent on being in the top-performing pair is roughly 50%, with the percentage monotonically increasing, the lower-ranked the pair. This pattern is predicted by our hypothesis and consistent with the presence of a sorting bias. We observe no significant gender difference in the incidence of the bias. This data indicate that the sorting bias is present in conjunction with a general disposition toward overplacement.

We go beyond prior studies to identify the patterns within-subject. Rather than documenting that high performers tend to underplace and lower performers to overplace themselves, as the previous studies cited in Section 2 have established, our within-subject design shows that a single individual will typically exhibit different degrees of overplacement depending on how they end up being sorted. Therefore, the tendency to under- or over-place oneself is not only a consequence of low- and high- ability individuals having different biases but also appears to involve one common bias that high and low achievers both exhibit. In the previous studies on this topic, it was not possible to observe the counterfactual beliefs held when people who are higher (lower) performers would have instead performed badly (well).

We believe that individuals have a predisposition toward overplacement. A belief of greater than 50% that one will outperform a peer is the reference point of the typical individual. When selected into an elite group, the sorting bias reduces this overconfidence. Individuals perceive this reduction from a reference state of overconfidence negatively and feel it as an adverse state. If the sorting bias of an individual is strong enough, this individual would then underplace herself relative to others. This is consistent with the behavior of some individuals in our study and commonly observed in prior studies.

Our study does not allow us to identify the mechanisms behind the sorting bias. However, there are several possibilities that we find plausible.

1. One possibility is that individuals place too much weight on their prior beliefs about their ability and too little on the test score that they have just received. So, for example, if the individual believes that she has average ability at the task, she believes that a very good or very poor score on the first test does not reflect her actual ability, and that she may have been sorted inappropriately. If an individual holds biased positive prior beliefs about her own ability, this effect would tend to contribute to overplacement more generally.
2. There may be stress induced by the prospect of competing against better performers. This stress might induce relatively pessimistic beliefs when one is assigned to a high-performing group.
3. An individual may update her belief about her own ability less than her beliefs about others, because she has a lot of previous data and experience regarding her own ability, but has little to no data about the ability of others.
4. It may be the case that there is a tendency to attribute one's own performance, whether good or bad, to luck and others' performance to their ability. In other words, individuals take into account their own luck to a greater extent than the luck of others.
5. There may be self-image considerations where one is reluctant to admit to oneself that one might lose to those with low ability. This prompts the individual to hold more optimistic beliefs when in lower performing groups. Similar self-image concerns can also contribute to general overconfidence.

The assertions above regarding possible drivers of the sorting bias are speculative, but all are consistent with what we have observed. Future experimental studies can try to distinguish among these and other potential explanations. One interesting follow-up experiment would involve eliciting predictions of actual performance of an individual and her opponent. This would allow us to measure how much their belief about an opponent's performance changes when their group level changes and compare it to how much their belief about their own performance changes. This would help us identify the mechanism behind the sorting bias and determine whether it is a mechanism that we propose.[5] An important and interesting agenda for future work is to study how to debias beliefs so as to reduce both the sorting bias and overconfidence.

The study, like any other, has limitations. The first major limitation is that our conjectures about the psychological mechanisms underlying the sorting bias are in the realm of speculation for the moment. Follow-up studies are required to rule out any of the explanations or to distinguish among them. The Fundamental Attribution Error, a bias in which the characteristics of a person are overweighted and external factors are underweighted, if it is applied differentially to oneself and one's partner, can underpin the first and fourth of the conjectures above. The idea would be that participants tend to believe that a characteristic of others, such as their mathematical ability, for example, is stable, while their own performance is situational.

The second limitation is that we have considered placement level only in a single activity, mathematics tests. It may be the case that behavior could differ for another activity, such as one that puts greater weight on effort than on pure ability. A third limitation is it is possible that there is a broader underlying bias at work that may lead to a pattern similar to the sorting bias that we have observed. If so, a good approach would be to try to identify this broader bias. We view this study as only one step in understanding the basis of over-and under-placement.

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