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Abstract: We experimentally investigate the memory recall bias of overconfident (underconfident) individuals after receiving feedback on their overconfidence (underconfidence). Our study differs from the literature by identifying the recall pattern conditional on subjects' overconfidence/underconfidence. We obtain the following results. First, overconfident (underconfident) subjects exhibit overconfident (underconfident) recall despite receiving feedback on their overconfidence (underconfidence). Second, awareness of one's overconfidence or underconfidence does not eliminate memory recall bias. Third, the primacy effect is stronger than the recency effect. Overall, our results suggest that memory recall bias is mainly due to motivated beliefs of sophisticated decision makers rather than naïve decision-making.

Keywords: memory recall bias; overconfidence; underconfidence; experiment

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1. Introduction

> "One of the keys to happiness is a bad memory."
>
> Rita Mae Brown

This paper experimentally investigates the memory recall bias of overconfident (underconfident) decision makers after they receive feedback on their overconfidence (underconfidence). Studies show that many individuals are overconfident or underconfident in different decision-making contexts, including investment (Malmendier and Tate, 2005 [1]; Barber and Odean, 2001 [2]), bargaining (Neale and Bazerman, 1985 [3]), and market entry decisions (Camerer and Lovallo, 1999 [4]). The decision maker may be motivated to hold biased beliefs because of the pleasure of a positive self-image (e.g., Bénabou and Tirole, 2002 [5]) or to motivate himself/herself to work harder (e.g., Compte and Postlewaite, 2004 [6]).

An important question that remains to be answered is whether overconfident (underconfident) decision makers will exhibit *memory recall bias* after receiving feedback on their overconfidence (underconfidence). This is an important question because it can determine whether an individual's memory bias is due to "error" or motivated beliefs. If it is due to error (i.e., the individual is naïve), then this bias is likely to be reduced significantly when individuals learn from their feedback. However, if this bias arises due to motivated beliefs (i.e., the individual is sophisticated), then these beliefs are likely to remain unchanged after feedback.

In the literature, memory recall bias is often measured in the following way. Subjects perform a task and are informed of the outcome of the task. Then, after some time, the subjects are asked to recall their performance in the task. This approach has several drawbacks. It cannot determine whether an individual's memory recall bias is due to error or motivated beliefs because it provides no information regarding individuals' "preferences" for biased beliefs (e.g., overconfidence or underconfidence). (In using the term "preference," we refer to the fact that individuals may be overconfident/underconfident because of motivations such as maintaining their self-image or inducing greater effort.) For example, if an individual is found to have overconfident recall, the method will not distinguish between error (e.g., because of random choice) or motivated beliefs as the cause. Another drawback is that this approach does not provide answers to the question of whether individuals will exhibit memory recall bias when they are aware of their own bias.

In the current study, we propose a design that can (1) investigate the heterogeneity of memory recall bias by taking individuals' preferences for overconfidence/underconfidence into account; (2) investigate if individuals exhibit memory recall bias even if they are aware of their own bias. To the best of our knowledge, this is the first study on the memory recall of overconfident/underconfident decision makers after feedback on their overconfidence/underconfidence, using the methodology of experimental economics. (For an extensive literature review on overconfidence and underconfidence, see Moore and Schatz (2017) [7].)

We conduct an experiment consisting of a laboratory experiment and an online memory recall experiment. In the laboratory experiment, the subjects participate in five rounds of an incentivized word entry task, and they are asked to forecast (incentivized) their number of mistakes and ranking in accuracy before receiving feedback. This experiment allows us to identify whether the subjects are overconfident/underconfident, and makes the subjects aware (Modica and Rustichini, 1994 [8]) of their own overconfidence/underconfidence. In the online memory recall experiment, the subjects are asked to recall their performance in the word entry task.

Several papers study memory recall bias using the methodology of experimental economics. Li (2013) [9] asks subjects to participate in a simplified trust game, and the subjects are asked to recall the choice of the other player 0, 7, and 43 days after the respective treatments. Li (2013) [9] finds evidence of memory recall bias. More specifically, a victim of an unkind act is more likely to forget than someone who benefited from a kind act, a result supporting the idea that individuals may strategically manipulate their memory by forgetting an unpleasant experience. (See Saucet and Villeval (2018) [10] for a study of memory in the dictator game.)

Chew et al. (2020) [11] conduct an experiment in which subjects participate in an IQ test and are asked to recall if they did it correctly. They find that a significant proportion of subjects had false memories in the sense of forgetting that they had completed the test incorrectly. The key difference between our experimental design and that of Chew et al. (2020) [11] is the subjects' awareness of their own overconfidence/underconfidence. The subjects in our experiment make multiple forecasts of their performance and are given multiple instances of feedback on their forecasts immediately after they make their forecasts and before they participate in the recall task. In contrast, the subjects in Chew et al. (2020) [11] do not make forecasts and, as a result, there is no information regarding their preferences for overconfidence/underconfidence or awareness. We are interested in determining whether overconfident (underconfident) subjects in the lab experiment will exhibit overconfident (underconfident) recall 40 days after receiving feedback on their overconfidence/underconfidence in the lab.

Zimmermann (2020) [12] studies the dynamics of motivated beliefs after noisy feedback. Subjects participate in an IQ test and are asked to forecast their ranking in a group of 10 subjects. Then, for each subject, the experimenter randomly selects three other group members, and informs the subject regarding whether he/she is ranked higher or lower than these three members. The feedback is noisy because the subject is not told his or her actual rank among the 10 subjects in the group. After the noisy feedback, Zimmermann (2020) [12] elicits the subjects' beliefs regarding their positions in the group for a second time. The recall treatment of Zimmermann (2020) [12] is the study closest to the recall part of our experiment. In his treatment, subjects are asked how many of the three comparisons are positive (meaning that the subject ranks higher than the respective members). He finds that positive feedback (good news) has a persistent effect on beliefs, whereas the effect of negative feedback (bad news) is more short-run in nature, and that subjects recall negative feedback with less accuracy than is the case for positive feedback. (In Zimmermann

(2020) [12], subjects who receive positive feedback are those who learned that they ranked higher than at least two of the three randomly selected group members, with all others being classified as receiving negative feedback.) In particular, subjects who receive negative feedback tend to misremember in an optimistic fashion.

Our design differs from that of Zimmermann (2020) [12] in several important aspects. First, the subjects in our experiment make forecasts on their ranking and number of mistakes, whereas in Zimmermann (2020) [12] subjects do not make forecasts. Requiring subjects to make forecasts before they are informed of their actual performance allows us to observe whether a subject is overconfident/underconfident before receiving feedback, and condition his or her subsequent recall behavior on his or her identified type. Furthermore, in our design, the subjects are aware of their overconfidence/underconfidence. Thus, in the subsequent recall task after 40 days, we can investigate whether the subject can recall whether he or she is overconfident/underconfident in the forecasts, conditional on his or her overconfidence/underconfidence in the lab, in addition to recalling his or her actual performance in the ranking and number of mistakes. Second, in our study, feedback is perfect (in the sense that subjects are told their exact ranking and number of mistakes in the word entry task) rather than noisy.

Our paper is related to two streams of theoretical frameworks on motivated beliefs in the literature. The first is based on biased belief formation (e.g., Bénabou and Tirole, 2002 [5]; Brunnermeier and Parker, 2005 [13]) and the second on Bayesian learning (Benoît and Dubra, 2011 [14]). Bénabou and Tirole (2002) [5] present a model of endogenous memory to capture the self-deception phenomenon. In their model, the decision maker can follow Bayesian updating while maintaining motivated beliefs, and the decision maker may be motivated to hold a biased belief to maintain a positive self-image or for social signaling. The decision maker faces a trade-off between gaining utility from a positive self-image and becoming overconfident. (See Carrillo and Mariotti (2000) [15], Compte and Postlewaite (2004) [6], Brunnermeier and Parker (2005) [13], Santos-Pinto and Sobel (2005) [16], and Köszegi (2006) [17] for models in which individuals may be motivated to hold biased beliefs.) One implication of the model is that the decision maker may exhibit self-deception when recalling his or her memory. Bénabou and Tirole (2002) [5] use a multiple-self model with imperfect recall in which the decision maker exhibits memory recall bias by forgetting the bad signal, so that future selves do not suffer from present bias.

In another paper, Compte and Postlewaite (2004) [6] present a model in which overconfidence can enhance performance. (See Chen and Schildberg-Hörisch (2019) [18] and Yin et al. (2019) [19] for two recent experimental works showing that overconfidence can lead to higher level of effort or investment.) Benoît and Dubra (2011) [14] present a theory in which overconfidence can arise when individuals have incomplete information regarding their abilities. In other words, the individuals are not overconfident but appear to be (i.e., apparent overconfidence). One implication of Benoît and Dubra (2011) [14], for the context of our experiment, is that if individuals are driven by incomplete information, they are less likely to be overconfident after receiving feedback. If overconfidence is greatly reduced after receiving feedback, this would suggest that, in most cases, overconfidence is apparent overconfidence.

In Brunnermeier and Parker's (2005) [13] optimal expectations model, the decision maker's trade-off is between being optimistic and the costs of poor decision-making. In this setting, the decision maker is biased toward optimism and is overconfident.

In biased belief models, for example, Bénabou and Tirole (2002) [5] and Compte and Postlewaite (2004) [6], these beliefs are predicted to be persistent and thus not easily eliminated by receiving feedback. In other words, the decision maker holding motivated beliefs is "sophisticated" rather than "naïve". Note that our investigation differs from the usual investigations of learning in the following sense. Typically, studies of learning largely concern learning about an external state. However, in our setting, learning concerns one's skills and there is an incentive to be biased because learning can threaten one's self-image. As a result, it is not obvious that learning will necessarily lead to unbiased beliefs eventually.

The main findings of our study can be summarized as follows. First, we show that a significant proportion of overconfident (underconfident) subjects exhibits overconfident (underconfident) recall despite receiving feedback on their overconfidence (underconfidence). Second, we find that most subjects can remember correctly whether they are overconfident in the Round 1 forecasts, suggesting that awareness of one's overconfidence (underconfidence) will not eliminate memory bias. Finally, we find that when multiple instances of feedback are given, individuals remember the first instance of feedback better, suggesting that the primacy effect (Murdock, 1962 [20]) dominates the recency effect (Murdock, 1962 [20]) in memory recall. The results suggest that individuals maintain their motivated beliefs even in the presence of feedback on their biased beliefs and being aware of their bias (Modica and Rustichini, 1994 [8]; Dekel, Lipman, and Rustichini, 1998 [21]). Although there is evidence of learning (which supports the idea that biased beliefs can be due to incomplete information on one's ability (Benoît and Dubra, 2011 [14]), learning itself cannot eliminate overconfidence or underconfidence in recall. Overall, our results suggest that memory recall bias is mainly due to the motivated biased beliefs (Bénabou and Tirole, 2002 [5]; Compte and Postlewaite, 2004 [6]; Brunnermeier and Parker, 2005 [13]) of sophisticated decision makers.

The rest of the paper is organized as follows. Section 2 presents the experimental design, Section 3 reports the experimental results, and Section 4 concludes the study.

2. Experimental Design

2.1. Part 1 (Laboratory Experiment)

The subjects participate in five rounds of the word entry task, see Figure 1 for the structure of the experiment. (Our word entry task complements the IQ test (Chew et al. 2020 [11]; Zimmermann (2020 [12]) showing the robustness of motivated memory under different underlying tasks.) Each round lasts 5 min. In each round, a subject is given a paper that contains 100 randomly generated words (see Figure 2 for an example). The subject's task is to enter the words in the exact format using the computer. The subject receives HKD 0.20 for each correctly entered word. The subject who enters the highest number of correct words receives an additional prize of HKD 100 (≈USD 12.80). If there is more than one winner, their names are randomly drawn to determine who receives the prize.

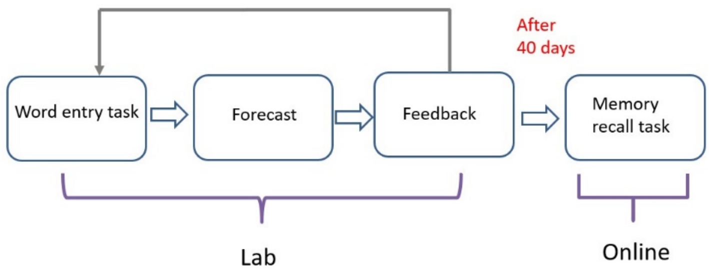

Figure 1. Structure of the Experiment.

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Sdfba safoafh afnhwofgowa woaf waf waoghw o geaoth ghre grig I highaiugh rieh gruih grhgrhreh re
huouh rouh re uhoreih ruhruhreauhouhouh hrohr jfei jfef jfejgpqf ofkqw wq wkqfkwq qwfkwq fwaf wag
ggeagea ehe high eag aweg wafg wag wa ghr hrt jy rik r6j te j reh w gh we y42 56 23 532 t 32 tgsd g sdg
we eeffgesg gh eefes hse hge erw ehr eh rege hge rw fgeag eage agea afgaweiorwjo warij0airj
2941roengoq fwjaipja jwpafjwa gjweapogja fiwapojf gjwoapgi gwjapgi
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Figure 2. Example of the Word Entry Task.

At the end of each round, each subject is asked to forecast the number of mistakes that he or she made out of the total number of words entered, and his or her ranking in terms of the number of correct words entered in the round. The number of mistakes is counted in the following way: if the subject adds or misses typing one or more words, then all remaining words are counted as mistakes. Each added or missing letter of a particular word is counted as one mistake.

The payoff on the number of mistakes forecast out of the number of words that the subject entered = 30 − 0.1 (actual number of mistakes − forecast number of mistakes)^2.

The subject's payoff on the ranking forecast = 30 − 0.2 (actual ranking − forecast ranking)^2.

At the end of each round, the subjects receive feedback on their actual ranking, the actual number of mistakes in the words entered, and the actual number of mistakes out of 100 words. The subjects participate in five rounds of the word entry task. At the end of the experiment, one round (and one of the payoffs in that round) is randomly drawn for payment. One hundred and seventy-six subjects participate in 13 sessions of the laboratory experiment; the number of subjects in each session ranges from 10 to 17. All of the subjects are university students from a major university in Hong Kong and are randomly recruited from a poll of approximately 3000 subjects using an e-mail recruitment system. Each subject participates in only one of the sessions. The experiment takes place in a laboratory where the subjects are randomly seated in partitioned cubicles. They are informed that their decisions are anonymous and confidential. Each session lasts about 50 min and the subjects receive a show-up fee of HKD 40.

2.2. Part 2 (Memory Recall Experiment)

In Part 2, the subjects of the laboratory experiment are invited by e-mail to participate in an incentivized online survey experiment. For participating in the survey, the subjects receive a participation fee of HKD 20 and an additional amount of money if they answer the questions correctly. Eighty-eight subjects (i.e., 50% of the 176 subjects who participated in the laboratory experiment) participate in the online experiment. The following questions are asked (see Table 1 for the summary):

1. What was your ranking in terms of the number of mistakes in the last round? Your payoff for this question will be determined by the following formula: HKD 20 − 0.5 (actual ranking − your answered ranking in this question)^2.
2. What was your number of mistakes in the word entry task in Round 5 out of the total number of words (100 words) in the paragraph? Your payoff for this question will be determined by the following formula: HKD 20 − 0.5 (actual number of mistakes − your answered number of mistakes in this question)^2.
3. Were you overconfident in your forecast of the number of mistakes in Round 5 (i.e., was your forecast number of mistakes lower than the actual number of mistakes, e.g., you forecast 10 mistakes, but you actually made 15 mistakes)? You will receive HKD 5 if your answer is correct, and zero otherwise.
4. Were you overconfident in your forecast of your ranking in Round 5 (i.e., was your forecast ranking lower than the actual ranking, e.g., you were ranked number 10, but you forecast yourself to be number 5)? You will receive HKD 5 if your answer is correct, and zero otherwise.
5. Were you overconfident in your forecast of the number of mistakes in Round 1 (i.e., was your forecast number of mistakes lower than the actual number of mistakes, e.g., you forecast 10 mistakes, but you actually made 15 mistakes)? You will receive HKD 5 if your answer is correct, and zero otherwise.
6. Were you overconfident in your forecast of your ranking in Round 1 (i.e., was your forecast ranking lower than the actual ranking, e.g., you were ranked number 10, but you forecast yourself to be number 5)? You will receive HKD 5 if your answer is correct, and zero otherwise.
7. In the experiment, you participated in the word entry task for five rounds. In the ranking forecasts, in how many rounds were you overconfident (i.e., was your forecast ranking lower than the actual ranking, e.g., you were ranked number 10, but you forecast yourself to be number 5)? You will receive HKD 5 if your answer is correct, and zero otherwise.

8. In the experiment, you participated in the word entry task for five rounds. In terms of the number of mistakes forecast out the number of words you entered, in how many rounds were you overconfident (i.e., was your forecast number of mistakes lower than the actual number of mistakes, e.g., your forecast number of mistakes was 10, but you actually made 15 mistakes)? You will receive HKD 5 if your answer is correct, and zero otherwise.

Table 1. Summary of Memory Recall Questions.

	Recalling on
1.	Round 5 rank
2.	Round 5 mistake
3.	Overconfidence of forecast (mistake) in Round 5
4.	Overconfidence of forecast (rank) in Round 5
5.	Overconfidence of forecast (mistake) in Round 1
6.	Overconfidence of forecast (rank) in Round 1
7.	Total number of overconfident forecast (rank)
8.	Total number of overconfident forecast (mistake)

3. Experimental Results

3.1. Laboratory Experiment

Figure 3 reports the proportion of subjects with overconfident rank and mistake forecasts across the rounds in the laboratory experiment (see also Table 2). A subject is classified as overconfident (rank) if his or her forecast rank is higher than his or her actual rank. A subject is classified as overconfident (mistake) if his or her forecast number of mistakes is lower than the actual number of mistakes. We find that in Round 1, the proportion of subjects with overconfident (rank) forecasts is 0.40, and the proportion for overconfident (mistake) forecasts is 0.57. It is evident that, after feedback, the proportions of subjects with overconfident (rank) and (mistake) forecasts in Round 5 drop to 0.20 and 0.31, respectively.

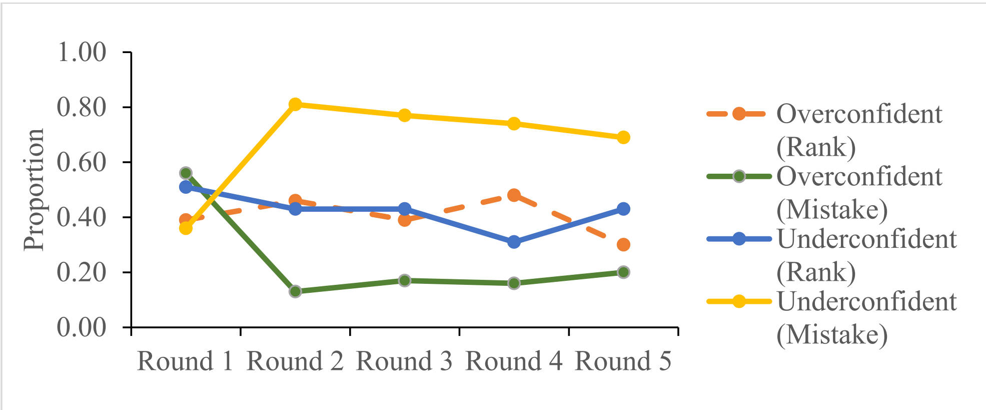

Figure 3. Proportion of Subjects with Overconfident and Underconfident Forecast.

Table 2. Proportion of Subjects with Overconfident/Underconfident Forecasts.

Forecast	Round 1	Round 2	Round 3	Round 4	Round 5
Overconfident					
Number of mistakes	0.57	0.13	0.17	0.16	0.20
Ranking	0.40	0.47	0.40	0.49	0.31
Underconfident					
Number of mistakes	0.36	0.81	0.77	0.74	0.69
Ranking	0.51	0.43	0.43	0.31	0.43

The proportion of subjects with overconfident (mistake) forecasts is significantly lower in Round 5 than in Round 1, with a p-value equal to 0.00 under the two-sample test of proportions. (The average correct rate (i.e., the correct number divided by the total number of words entered) in rounds 1, 2, 3, 4, and 5 are 0.66, 0.88, 0.87, 0.88, and 0.86, respectively. It seems that subjects became more conservative in their forecast on number of mistakes after seeing their first-round performance.) The proportion of subjects with overconfident (rank) forecasts is lower (weakly significant) in Round 5 than in Round 1, with a p-value equal to 0.06 under the two-sample test of proportions. This supports the idea that feedback can reduce the degree of overconfidence. Conversely, there is no significant difference between the proportions of subjects with underconfident (rank) forecasts in Rounds 1 and 5, whereas the proportion for underconfident (mistake) forecasts in Round 5 is significantly higher than in Round 1, with a p-value equal to 0.00 under the two-sample test of proportions.

Result 1: In the laboratory experiment, feedback significantly reduces overconfidence.

Social Comparison

We can investigate the proportion of overconfident subjects in terms of relative performance vs. absolute performance in the laboratory task. Our investigation is related to the literature on social comparison theory (Festinger, 1954 [22]; Wills, 1981 [23]) in social psychology. (See also Charness et al. (2013) [24] and Gill et al. (2018) [25] for the impact of rank on status.) One implication of social comparison theory is that individuals derive joy from a belief in high relative performance, whereas they derive relatively little joy from a belief in high absolute performance. Hence, individuals will be more likely to exhibit overconfidence in the social comparison context. (According to Moore and Schatz (2017) [7], there are three types of overconfidence: overestimating one's actual performance, overplacement of one's performance relative to others, and excessive precision in one's beliefs. Thus, the social comparison motivation is more related to overplacement.)

From Figure 3, it can be seen that in Round 1, the proportion of subjects with overconfident (mistake) forecasts is 0.57, which is higher than 0.40, the proportion of subjects with overconfident (rank) forecasts. The difference is significant with a p-value equal to 0.00 under the two-sample test of proportions. However, the pattern is reversed in Round 2. That is, the proportion of subjects with overconfident (rank) forecasts is higher than that for overconfident (mistake) forecasts. The difference is significant with p-values equal to 0.00 (Rounds 2, 3, and 4) and 0.02 (Round 5) under the two-sample test of proportions. This suggests that individuals are more likely to exhibit overconfidence in social comparisons, supporting the social comparison theory (Festinger, 1954 [22]; Wills, 1981 [23]).

3.2. Memory Recall

Table A1 in Appendix A reports the comparisons of main variables of interest (i.e., performance in part 1, overconfidence in forecast, and underconfidence in forecast) between subjects participating in both part 1 and 2 and those only participating in part 1. It confirms that there are no systematic, significant differences between the former and the latter.

Table 3 reports the proportions of subjects with overconfident, underconfident, and correct recall on the four key recalling items: total number of overconfident forecasts in the five rounds (rank), total number of overconfident forecasts in the five rounds (mistake), Round 5 ranking, and number of mistakes in Round 5. (Overconfident (underconfident) recall can be alternatively labeled as false positive (negative) memory.) In the aggregate (recalling the total number of overconfident forecasts), 32% of the subjects have overconfident recall (ranking), 37% are underconfident (ranking), 12% are overconfident (mistake), and 69% are underconfident (mistake). When recalling Round 5 rankings, 18% are overconfident and 37% are underconfident. When recalling the number of mistakes in Round 5, 65% are overconfident and 25% are underconfident.

Table 3. Recall Patterns.

	Overconfident Recall	Underconfident Recall	Correct Recall
Total number of overconfident forecasts in the five rounds (rank)	0.32	0.37	0.32
Total number of overconfident forecasts in the five rounds (mistake)	0.12	0.69	0.20
Round 5 rank	0.18	0.37	0.45
Round 5 number of mistakes	0.65	0.25	0.11

3.2.1. Overconfident Recall

We compare the proportion of subjects with overconfident recall between subjects with three or more overconfident rank forecasts (41.7% of the subjects) and those with less than three overconfident forecasts, and between subjects with three or more overconfident mistake forecasts (11.9% of the subjects) and those with less than three overconfident forecasts.

Table 4 reports the comparison of overconfident recall between the two groups of subjects for each of the respective types of forecasts. We find that those with three or more overconfident forecasts are significantly (under two-sample test of proportions) more likely to exhibit overconfident recall when recalling the total number of overconfident forecasts (rank and mistake), the Round 5 rank, and the Round 5 mistake, than are those with less than three overconfident forecasts. As a robustness check, we also conduct the comparisons based on whether the subject has at least four overconfident forecasts, as well as whether the subject has at least four underconfident forecasts, and find similar results, see Tables A2 and A3 in Appendix A. In summary, the results suggest that those with overconfident forecasts are more likely to exhibit overconfident recall despite having received feedback.

Table 4. Comparison of Overconfident Recall Conditional on Overconfidence in Forecasts.

	Three or More Overconfident Forecasts	N	Less than Three Overconfident Forecasts	N	Proportion Test *p*-Value
Overconfident recall on total number of overconfident forecasts					
Rank	0.51	35	0.18	49	0.00 ***
Mistake	0.40	10	0.08	74	0.00 ***
Overconfident recall on Round 5 forecasts					
Round 5 rank	0.33	33	0.08	51	0.00 ***
Round 5 mistake	1.00	9	0.61	76	0.02 **

Notes: ** and *** denote significance at the 5%, and 1% levels, respectively.

3.2.2. Underconfident Recall

Table 5 shows that the subjects with three or more underconfident forecasts are more likely to exhibit underconfident recall than those who have less than three underconfident forecasts.

Table 5. Comparison of Underconfident Recall Conditional on Underconfidence in Forecasts.

	Three or More Underconfident Forecasts	N	Less than Three Underconfident Forecasts	N	Proportion Test *p*-Value
Underconfident recall on total number of overconfident forecasts					
Rank	0.58	24	0.28	60	0.01 **
Mistake	0.76	63	0.48	21	0.01 **
Underconfident recall on Round 5 forecasts					
Round 5 rank	0.56	25	0.29	59	0.02 **
Round 5 mistake	0.28	64	0.14	21	0.20

Notes: ** denotes significance at the 5%.

Result 2: Overconfident (underconfident) subjects exhibit overconfident (underconfident) recall despite having received feedback on their overconfidence (underconfidence).

3.2.3. Proportion of Correct Recall on Overconfidence in Forecasts

Table 6 reports the proportion of correct recall on whether the subjects were overconfident in their forecasts in Rounds 1 and 5, conditional on their forecast types. It is evident that the subjects can recall whether they were overconfident in Round 1 forecasts quite accurately. In particular, conditional on exhibiting overconfident forecasts, the percentages of correct recall for overconfident forecasts in Rounds 1 and 5 rankings are 82% and 57%, respectively, and those for Rounds 1 and 5 mistakes are 79% and 50%, respectively. Conditional on exhibiting underconfident forecasts, the percentages of correct recall for overconfident forecasts in Rounds 1 and 5 rankings are 82% and 77%, respectively, and those for Rounds 1 and 5 mistakes are 69% and 57%, respectively. These results suggest that awareness of overconfidence or underconfidence will not eliminate memory bias. (There is no significant gender difference between subjects who can recall overconfidence in forecasts and those who cannot. Further, there is no significant difference in ranking and number of mistakes, except that subjects who recall correctly their round 1 overconfidence in mistake forecast have higher number of mistakes than those who cannot. This suggests that whether one can recall his/her overconfidence in forecasts is not correlated with the performance in the tasks or their gender).

Table 6. Recall on Overconfidence in Forecasts.

	Correct Recall	N
Overconfident forecast (Round 1 rank)	0.82	28
Underconfident forecast (Round 1 rank)	0.82	50
Overconfident forecast (Round 5 rank)	0.57	28
Underconfident forecast (Round 5 rank)	0.77	35
Overconfident forecast (Round 1 mistake)	0.79	47
Underconfident forecast (Round 1 mistake)	0.69	29
Overconfident forecast (Round 5 mistake)	0.50	18
Underconfident forecast (Round 5 mistake)	0.57	58

Result 3: Most subjects can remember correctly whether they were overconfident in the Round 1 forecasts, suggesting that awareness of overconfidence or underconfidence will not eliminate memory bias.

3.2.4. Memory Recall Bias and Bias in Forecast

This subsection analyzes the following question: conditional on exhibiting overconfident (underconfident) recall, what is the proportion of subjects who also exhibit overconfident (underconfident) forecast? We find that 66.7% of the subjects who exhibit overconfident recall on the number of overconfident forecasts (rank) are those with at least three instances of overconfident forecasts (rank); 45.2% of the subjects who exhibit underconfident recall on the number of overconfident forecasts (rank) are those with at least three instances of underconfident forecasts (rank); 40% of the subjects who exhibit overconfident recall on the number of overconfident forecasts (mistake) are those with at least three instances of overconfident forecasts (mistake); 83% of the subjects who exhibit underconfident recall on the number of overconfident forecasts (mistake) are those with at least three instances of underconfident forecasts (mistake). Again, this suggests that a substantial proportion of subjects exhibit memory recall bias despite receiving feedback on their overconfidence or underconfidence, and that their memory recall bias is motivated.

3.3. Other Results on Memory Recall

3.3.1. Recall of Good News vs. Bad News

We find that when recalling whether they were overconfident in Round 1 forecasts (rank), 82% of the overconfident subjects can recall correctly, which is not significantly different from the percentage observed for underconfident subjects. Similarly, the proportion of correct recall on overconfidence in Round 1 (number of mistakes) is not significantly different between overconfident and underconfident subjects. A similar pattern is found for Round 5 rank and mistake. Taken together, these results suggest that good news (i.e., the actual outcome being better than the forecast) is not recalled more accurately than bad news. Relatedly, Zimmermann (2020) [12] finds that positive feedback has a persistent effect on beliefs, whereas the effect of negative feedback is more short-run in nature, and subjects recall it with less accuracy. Conditional on individuals' overconfidence or underconfidence, we find that individuals choose to misremember according to their confidence type rather than necessarily misremembering bad news more than good news.

3.3.2. Primacy Effect vs. Recency Effect

We find that when recalling whether they were overconfident in their forecasts of the number of mistakes out of the words entered, 75% of the subjects are correct for Round 1, but the percentage drops to 55% for Round 5, see Figure 4. The difference is significant with a p-value equal to 0.01 under the two-samples test of proportions. When recalling whether they were overconfident in their forecasts for ranking, 81% of the subjects are correct for Round 1, and 66% are correct for Round 5. The difference is significant with a p-value equal to 0.03 under the two-sample test of proportions. This suggests that individuals have a better memory of their first forecast than of their last forecast. In summary, the primacy effect (remembering the first round better) is stronger than the recency effect (remembering the last round better). One possible reason that primacy effect is stronger could be due to the subjects being tired or bored in the later rounds and thus having a weaker memory.

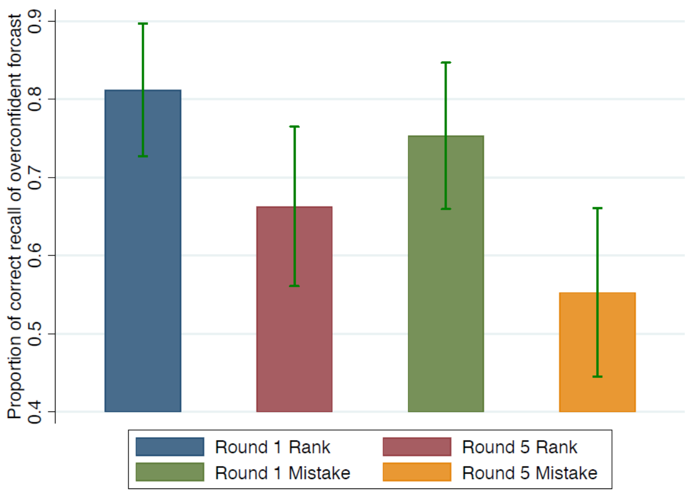

Figure 4. Proportion of Correct Recall of Overconfident Forecasts.

Result 4: The primacy effect (remembering the first round better) is stronger than recency effect (remembering the last round better).

4. Discussion

This paper uses a novel design to investigate whether overconfident (underconfident) decision makers exhibit memory recall bias after receiving feedback on their overconfidence (underconfidence). Our study differs from the literature by identifying the recall pattern conditional on subjects' overconfidence/underconfidence, and by providing feedback on the subjects' overconfidence (underconfidence). We find that overconfident (underconfident) decision makers are likely to exhibit overconfident (underconfident) recall despite having received feedback on their overconfidence (underconfidence). That is, overconfident subjects remain overconfident in recall, and underconfident subjects remain underconfident in recall. Our finding suggests that a significant proportion of subjects choose to hold their biased belief despite being aware (Modica and Rustichini, 1994 [8]) of it as a result of feedback. In summary, the results suggest that memory recall bias is mainly due to the motivated beliefs (Bénabou and Tirole, 2002 [5]) of sophisticated decision makers rather than to the naivety of decision makers. Our finding is consistent with the idea that the decision maker is motivated to hold biased beliefs due to positive self-images (e.g., Bénabou and Tirole, 2002 [5]) or to motivate himself/herself to work harder (e.g., Compte and Postlewaite, 2004 [6]).

Our results reveal the heterogeneity of memory recall bias; there is not only overconfident recall but also underconfident recall. In addition, we find that the subjects do not remember good news (when they are underconfident in their forecast) any better than they remember bad news (when they are overconfident in their forecast).

We find that decision makers remember the first feedback that they receive better than the last feedback. This result suggests that the primacy effect (Murdock, 1962 [20]) is stronger than the recency effect (Murdock, 1962 [20]).

Several interesting questions can be investigated in future research. First, it will be interesting to examine the implications of memory recall bias on market behavior. For example, investors with memory recall bias may be motivated to forget their investment performance (see, e.g., Li and Rong, 2019 [26]). Second, it will be interesting to investigate the relationship between long-term memory and short-term memory. Third, it will be interesting to investigate the memory recall strategy from the perspective of self-control (Gul and Pessendorfer, 2001 [27]). A decision maker with present bias may be motivated to hold a biased belief (e.g., forgetting poor performance events, and remembering good performance events) as it offers utility for the present moment. However, it comes at the cost of poor decision-making in the future because negative events may be associated with valuable information that is forgotten along with the negative events. Anticipating the cost, will a decision maker be willing to commit to receiving reminders on the "facts"?

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Institutional Review Board Statement: This research was approved by the human subjects ethnic committee of City University of Hong Kong (application number H001112).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data for the experiment can be downloaded from https://doi.org/10.3886/E162901V1, accessed on 1 March 2022.

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Appendix A

Table A1. Comparisons on Main Variables between Subjects Who Participate in Part 1 Only and Those Who Participate in Both Parts 1 and 2.

	Participate in Part 1 Only	Participate in Both Parts 1 and 2	*t*-Test *p*-Value
Performance			
Ranking (Round 1)	7.62	5.87	0.00 ***
Ranking (Round 2)	7.05	6.47	0.32
Ranking (Round 3)	7.41	6.44	0.09 *
Ranking (Round 4)	7.46	6.73	0.22
Ranking (Round 5)	7.13	6.45	0.24
Number of mistakes (Round 1)	31.44	21.47	0.02 **
Number of mistakes (Round 2)	8.99	6.02	0.18
Number of mistakes (Round 3)	10.14	5.35	0.02 **
Number of mistakes (Round 4)	9.09	5.84	0.13
Number of mistakes (Round 5)	10.37	7.47	0.34
Overconfident Forecast			**proportion test *p*-value**
Ranking (Round 1)	0.46	0.35	0.13
Ranking (Round 2)	0.38	0.55	0.02 **
Ranking (Round 3)	0.39	0.42	0.74
Ranking (Round 4)	0.45	0.54	0.23
Ranking (Round 5)	0.29	0.33	0.58
Number of mistakes (Round 1)	0.59	0.55	0.63
Number of mistakes (Round 2)	0.15	0.11	0.47
Number of mistakes (Round 3)	0.23	0.11	0.04 **
Number of mistakes (Round 4)	0.13	0.19	0.24
Number of mistakes (Round 5)	0.20	0.21	0.77
Underconfident Forecast			
Ranking (Round 1)	0.44	0.57	0.07 *
Ranking (Round 2)	0.49	0.36	0.07 *
Ranking (Round 3)	0.49	0.37	0.10 *
Ranking (Round 4)	0.46	0.26	0.16
Ranking (Round 5)	0.47	0.39	0.30
Number of mistakes (Round 1)	0.37	0.35	0.78
Number of mistakes (Round 2)	0.79	0.82	0.65
Number of mistakes (Round 3)	0.75	0.80	0.42
Number of mistakes (Round 4)	0.79	0.70	0.14
Number of mistakes (Round 5)	0.70	0.69	0.82
Gender			
Female	0.59	0.69	0.17

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table A2. Comparison of Overconfident Recall Conditional on Overconfidence in Forecasts.

	Four or More Overconfident Forecasts	N	Less than Four Overconfident Forecasts	N	Proportion Test *p*-Value
Overconfident recall on total number of overconfident forecasts					
Rank	0.60	20	0.23	64	0.00 ***
Mistake	0.50	4	0.10	80	0.02 **
Overconfident recall on Round 5 forecasts					
Round 5 rank	0.39	18	0.12	66	0.01 ***
Round 5 mistake	1	3	0.63	82	0.19

Notes: ** and *** denote significance at the 5%, and 1% levels, respectively.

Table A3. Comparison of Underconfident Recall Conditional on Underconfidence in Forecasts.

	Four or More Underconfident Forecasts	N	Less than Four Underconfident Forecasts	N	Proportion Test *p*-Value
Underconfident recall on total number of overconfident forecasts					
Rank	0.50	12	0.35	72	0.31
Mistake	0.84	43	0.54	41	0.00 ***
Underconfident recall on Round 5 forecasts					
Round 5 rank	0.67	12	0.32	72	0.02 **
Round 5 mistake	0.32	44	0.17	41	0.12

Notes: ** and *** denote significance at the 5%, and 1% levels, respectively.

Appendix B

Experimental Instructions for the Laboratory Experiment

Instructions

Welcome to our experimental study on decision-making. You will receive a show-up fee of HKD 40. In addition, you can gain more money as a result of your decisions in the experiment.

You will be given a subject ID number. Please keep it confidential. Your decisions will be anonymous and remain confidential. Thus, other participants will not be able to link your decisions to your identity. You will be paid in private, using your subject ID, and in cash at the end of the experiment.

When you have questions, please feel free to ask by raising your hand and one of our assistants will come to answer your questions. Please DO NOT communicate with any other participants.

You will participate in five rounds of the word entry task. At the end of the experiment, one round will be randomly drawn for payment. That is, your payment will be equal to the show-up fee of HKD 40 plus the payoff from the randomly drawn round.

There will be five rounds of the word entry task. Each round will last 5 min. In each round, you will be given a paper that contains some words. Your task is to enter the words in the exact format using the computer. You will receive HKD 0.20 for each correctly entered word. The participant who enters the highest number of correct words will receive an additional prize of HKD 100. If there is more than one winner, there will be a random draw to determine who will receive the prize.

At the end of each round, you will make a forecast on the number of mistakes you made out of the total number of words you entered, and your ranking in terms of the number of correct words in the round. The number of mistakes will be counted in the following way: if you add or miss typing one or more words, then the remaining words will be counted as mistakes. Each added or missing letters of a particular word will be counted as one mistake.

Your payoff on the number of mistakes forecast out of the number of words you have entered = $30 - 0.1(\text{actual number of mistakes} - \text{your forecast number of mistakes})^2$.

Your payoff on the ranking forecast = $30 - 0.2(\text{actual ranking–your forecast ranking})^2$.

Your payoff in each round will be based on your payoff from the word entry task or the payoff from forecasts on the number of mistakes or the payoff from forecasts on your ranking. We will randomly determine which method will be used.

At the end of the experiment, the subjects fill out a questionnaire regarding their degree of overconfidence, which includes the following three questions:

1. On a scale of 1 (not overconfident at all) to 10 (completely overconfident), how would you rate your degree of overconfidence in forecasting your number of mistakes in the word entry task?
2. On a scale of 1 (not overconfident at all) to 10 (completely overconfident), how would you rate your degree of overconfidence in forecasting your ranking in the word entry task?
3. Before participating in this experiment, were you aware that you might be overconfident?

Appendix C

Experimental Instructions for the E-mail and Survey Questions

E-mail

Dear Participants,

Thank you for your participation in the word entry experiment conducted on 24 November 2016. The experiment had five rounds and, in each round, you were given a paragraph to enter into the computer using notepad. We would like to invite you to participate in a survey regarding the experiment. By participating in the survey, you will receive a participation fee of HKD 20, and an additional amount of money if you can answer the questions correctly. Please participate in the survey by visiting the following link:

[Qualtrics link was provided here]

Thank you very much!

City University of Hong Kong Experimental Economics Laboratory

Questions

1. Please enter your student ID no. (please enter the information accurately, otherwise we will not be able to pay you).
2. Please enter your name (please enter the information accurately, otherwise we will not be able to pay you).
3. In the experiment, you participated in the word entry task for five rounds. In your session, there were [number was provided here] participants. What was your ranking in terms of the number of mistakes in the last round? Your payoff for this question will be determined by the following formula: HKD $20 - 0.5 \times$ (actual ranking $-$ your answered ranking in this question)^2.
4. What was your number of mistakes in the word entry task in Round 5 out of the total number of words (100 words) in the paragraph? Your payoff for this question will be determined by the following formula: HKD $20 - 0.5 \times$ (actual number of mistakes $-$ your answered number of mistakes in this question)^2.
5. Were you overconfident in your forecast on your number of mistakes in Round 5 (i.e., was your forecast number of mistakes lower than the actual number of mistakes, e.g., you forecast 10 mistakes, but actually made 15 mistakes)? You will receive HKD 5 if your answer is correct, and zero otherwise.
6. Were you overconfident in your ranking forecast in Round 5 (i.e., was your forecast ranking lower than your actual ranking, e.g., you were ranked number 10, but you forecast yourself to be number 5)? You will receive HKD 5 if your answer is correct, and zero otherwise.
7. Were you overconfident in your forecast on the number of mistakes in Round 1 (i.e., was your forecast number of mistakes lower than the actual number of mistakes, e.g., you forecast 10 mistakes, but you actually made 15 mistakes)? You will receive HKD 5 if your answer is correct, and zero otherwise.
8. Were you overconfident in the ranking forecast in Round 1 (i.e., was your forecast ranking lower than the actual ranking, e.g., you were ranked number 10, but you forecast yourself to be number 5)? You will receive HKD 5 if your answer is correct, and zero otherwise.
9. In the experiment, you participated in the word entry task for five rounds. In the ranking forecasts, in how many rounds were you overconfident (i.e., was your forecast ranking lower than the actual ranking, e.g., you were ranked number 10, but you forecast yourself to be number 5)? You will receive HKD 5 if your answer is correct, and zero otherwise.
10. In the experiment, you participated in the word entry task for five rounds. In terms of the number of mistakes you forecast out of the number of words you entered, in how many rounds were you overconfident (i.e., was your forecast number of mistakes lower than the actual number of mistakes, e.g., you forecast 10 mistakes, but you actually made 15 mistakes)? You will receive HKD 5 if your answer is correct, and zero otherwise.

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