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Real-life investors' memory recall bias: A lab-in-the-field experiment

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ABSTRACT

We conduct a lab-in-the field experiment to investigate the memory recall bias of real-life investors who are asked to recall their best performing stock (BPS) and worst performing stock (WPS). We have four main findings. First, investors are more likely to forget WPS than BPS. The proportion of investors who forget WPS and remember BPS is higher than that of those who forget BPS and remember WPS. Second, less experienced investors are more likely to forget WPS than more experienced investors. Third, present biased investors are more likely to forget WPS. Four, investors who pay more attention to stock prices are more likely to forget WPS. Overall, our findings suggest that investors exhibit motivated memory recall bias.

"*Blessed are the forgetful, for they get the better even of their blunders.*"

Friedrich Nietzsche

"*One of the keys to happiness is a bad memory.*"

Rita Mae Brown

1. Introduction

Life is difficult and memories are sometimes painful to recall. This fact has been recognized by many philosophers such as Friedrich Nietzsche who rightly pointed out that manipulating one's memory can help people to forget painful experience.

Do real-life investors exhibit memory recall bias when recalling their investment performance? Recent advances in theories of motivated beliefs (e.g., Bénabou and Tirole, 2002; Brunnermeier and Parker, 2005; Compte and Postlewaite, 2004; Chew et al., 2020) suggest that investors may be motivated to forget WPS due to the negative utility associated. However, it is largely unknown whether real-life investors exhibit *memory recall bias*. We conduct a lab-in-the-field experiment with real-life investors in Hong Kong to elicit their memories about their best performing stock (BPS) and their worst performing stock (WPS). To the best of our knowledge, this is the first study to investigate real-life investors' memory recall of investment performance.

A novel aspect of our experiment design is that our memory recall task takes place in a natural setting, where investors recall real-life investment decisions that they care about, instead of in a laboratory setting where they perform artificially. Although some studies investigate memory recall bias, most of them (e.g., Li, 2013; Saucet and Villeval, 2019; Chew et al., 2020; Zimmermann, 2020; Gödker et al., 2020; Li, 2022) use laboratory experiments. Huffman et al. (2020) investigate the memory recall bias of managers and that study appears to be the only study apart from our that uses a field setting.

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Several recent studies in experimental economics have documented evidence for memory recall bias in decision-makings, such as in recalling social interactions that involve moral decision-making (Li, 2013; Saucet and Villeval, 2019) and performance (Chew et al., 2020; Zimmermann, 2020; Li, 2022).[2] In an experiment on recalling choices in a simplified trust game, Li (2013) finds that a victim of an unkind act is more likely to forget than someone who benefits from a kind act. In Chew et al. (2020), subjects are asked to recall if they answered an IQ test correctly; they find that subjects tend to forget one had done it incorrectly. In Zimmermann (2020), subjects participate in an IQ test and are asked to forecast their ranking in a group after receiving feedback. He finds that subjects who receive negative feedback tend to misremember in an optimistic fashion. In Saucet and Villeval (2019), subjects recall their choices in binary dictator games. They find that subjects tend to remember their altruistic choice better than their selfish choices. In a laboratory experiment, Gödker et al. (2020) find that subjects over-remember positive investment outcomes and under-remember negative ones. More recently, Li (2022) finds that overconfident (underconfident) subjects exhibit overconfident (underconfident) recall despite having received feedback about their overconfidence (underconfidence), and majority of memory recall bias is due to motivated beliefs of sophisticated decision makers rather than naïve decision-making.

We propose a theory on investor's memory recall bias. Our simple theory is based on the framework that the investor faces an inter-temporal tradeoff on deciding whether to remember a negative outcome (i.e., WPS): remembering a negative outcome lowers one's current utility while it helps one learn from past mistakes and make better decisions in the future. Our theory is linked to the literature on motivated beliefs. In Bénabou and Tirole (2002), a time-inconsistent DM suppresses (forgets) bad news (signal) about her abilities to induce higher effort in the future.[3] Our model can be considered complementary to Bénabou and Tirole (2002) in the context of real-world decision-making. In Brunnermeier and Parker (2005), the decision-maker forms optimal expectation that has the trade-off between higher utility from biased belief (e.g., being overconfident) and the cost of poor decisions in the future. Our framework differs with the optimal expectation model of Brunnermeier and Parker (2005) in several ways. In our model, the decision maker in period 1 decides whether to remember or forget the investment outcome, while there is no such choice in Brunnermeier and Parker (2005). In Brunnermeier and Parker (2005), the decision-maker is unaware of whether his subjective probabilities differ from objective probabilities, leaving him unaware of his bias and unable to choose whether to remember or forget.[4] In contrast, in our model, the DM is well aware of his memory recall bias and can choose whether to remember or forget. Unlike in Brunnermeier and Parker (2005), uncertainty is completely/partially resolved in our model, naturally giving the DM the choice of remembering/forgetting.

Compte and Postlewaite (2004) develop a model in which being confident (e.g., perceived chance of success is higher than the objective chance of success) can increase the DM's probability of success. The idea is that overly optimistic beliefs will prompt the DM to undertake an activity and lead to a higher chance of success. An implication of their model is that correct perception does not maximize payoff in the long-term. The key difference between our model and that of Compte and Postlewaite (2004) is that in our model, when faced with bad news, remembering bad news (instead of forgetting it) helps increase the DM's probability of success. Further, there is no memory utility in Compte and Postlewaite (2004). In our model, the motivation to forget bad news is to eliminate negative memory utility rather than enhancing performance. Finally, in Compte and Postlewaite (2004), the agent does not choose his beliefs and his perceptions are subconscious.

Our main findings can be summarized as follows. First, we find that investors are more likely to forget WPS than BPS. The proportion of investors who forget WPS and remember BPS is higher than that of those who forget BPS and remember WPS. Second, less experienced investors are more likely to forget WPS than more experienced investors. Third, present biased investors are more likely to forget WPS. Four, investors who pay more attention on stock prices are more likely to forget WPS. Overall, our results suggests that investors exhibit motivated memory recall bias.

The rest of the paper is organized as follows. Section 2 reports the theory, and Section 3 reports the hypotheses and experimental design. Section 4 reports the experimental result. Section 5 concludes.

2. Theory

We propose a simple theory for the memory recall bias of investors based on the framework that the investor faces an inter-temporal tradeoff on deciding whether to remember a negative outcome (i.e., WPS): remembering a negative outcome (after the investment outcome is resolved) lowers one's current utility while it helps one learn from past mistakes and make better decisions in the future.[5]

Consider a risk neutral DM who faces a 3-period decision-making problem. The DM needs to make choice between option A and B in periods 0 and 2. We consider both options as investment projects and assume that the two options have equal chance (50%) of success.[6]

Period 0

The DM chooses between options A and B. However, in period 0, the DM does not know which option is better. The uncertainty will only be resolved in period 1. Denote the DM's irreversible choice in period 0 as D0.

Period 1

The uncertainty is resolved in period 1. Suppose, it turns out that A>B and the DM chooses B in period 0. In this case, the

[2] For theories of motivated beliefs, see e.g., Bénabou and Tirole (2002), Brunnermeier and Parker (2005), Compte and Postlewaite (2004), and Chew et al. (2020).

[3] See also Bénabou and Tirole (2011), Bénabou (2013), and Chew et al. (2020) for general frameworks that unify both hedonic and instrumental values of beliefs.

[4] In Brunnermeier and Parker (2005), "bias" means that the DM's subjective probability is different from the objective probability.

[5] WPS (BPS) corresponds to bad (good) outcome in our model.

[6] We assume that performance of A and performance of B are correlated in the sense that there is one and only one "correct" option among A and B in each period, and we assume that each option (A or B) has 50% chance of being the correct one. In addition, we assume that performance of options across periods are perfectly correlated, in the sense that if an option is the correct one in period 1, then it must also be the correct one in period 2. The assumption about the correlations between options and between periods is strong, but a reason that we make the extreme assumption and take the "shortcut" is to make the analysis more simple while we can still have a good understanding about how DM's decision of whether to remember or forget a good/bad news is affected by various underlying factors. Also, a justification of our assumption is that the performance of options may represent the investor's preference over the options. The investor does not know his preference initially, but it is fixed across time. So, as long as the uncertainty is resolved and the investor knows about his preference (and remembers it), then he will make the correct decision forever.

DM has made the wrong choice (bad news).[7] If B>A and the DM chooses B in period 0, then the DM has made the correct choice (good outcome). Now, the DM needs to decide whether to remember or forget the outcomes in period 1. If he chooses to remember, he will remember his preference ordering, and also the outcome of period 1. If he chooses to forget, he forgets everything (preference ordering and outcome) he learns from period 1. The choice to remember/forget affects the DM's payoff in the following way. Remembering a good outcome (news) gives the DM memory utility m in each of the periods in period 1 and period 2. Remembering a bad outcome gives the DM memory utility $-m$ in both periods 1 and 2. Assume that information is always valuable. Thus, remembering helps the DM make the correct choice in period 2. In other words, the utility of DM in period 1 if he makes the correct choice and chooses to remember $= x+m$. The utility of the DM in period 1 if he makes the correct choice and chooses to forget $= x$. The utility of DM in period 1 if he makes the wrong choice and chooses to remember $= -m$. The utility of DM in period 1 if he makes the wrong choice and chooses to forget is zero. It is clear that if the DM only considers period 1's utility, then remembering the good outcome dominates forgetting it. In contrast, forgetting bad outcome dominates remembering it.[8]

Period 2

The DM chooses between options A and B. If he makes the correct choice, he receives utility x, zero otherwise. The utility of DM in period 2 = memory utility from period 1 + utility from the choice in period 2. If the DM makes the wrong choice in period 0 and chooses to remember in period 1, then his utility in period $2 = -m + x$. If the DM makes the wrong choice in period 0 and chooses to forget in period 1, then his utility in period $2 = 0.5x$.

Choice of memory

Now, consider the decision to remember or forget in period 1 by taking period 2's payoff into consideration. It is obvious to see that when there is good news, it is optimal to remember. Let β be the weight for future utility. More precisely, following Bénabou and Tirole (2002), we assume that $\beta = \gamma\delta$, where δ is the standard discount factor and γ is the parameter for present bias. If $\gamma < 1$, then it means the DM has excessive preference for the present. The expected utility, from the view point of period 1, of DM for period 1 and period 2= utility in period $1+\beta$utility in period 2. In the case of bad news, the DM will choose to forget if $0 + \beta 0.5x > -m + \beta(-m + x)$. Rearrange, we have: $(1 + \beta)m > 0.5\beta x$.[9] The left-hand-side can be considered as the benefit of forgetting bad news. The right-hand-side can be considered as the cost of forgetting the bad news.[10] We can easily obtain the following predictions:

Proposition 1.

1. A higher x will lead to lower chance of forgetting bad news.
2. DM with lower β (i.e., discount future utility more heavily) will be more likely to forget bad news. This implies that (i) DM with lower γ (i.e., more present biased) will be more likely to forget bad news, and (ii) DM with lower δ (i.e., higher discount rate) will be more likely to forget bad news.
3. DM with higher m will be more likely to forget bad news.

A key determinant of the DM's behavior is the size of the parameter m. One possible factor that affects m is the attention of the DM that he puts on the decision-making problem. Research in neuroscience show that attention and memory are correlated (see e.g., Chun and Turk-Browne, 2007, for a review). In stock markets, the frequency at which the DM checks the stock price can be regarded as a proxy for attention on the choice of stocks. Karlsson et al. (2009) show that acquiring and attending to information increases the psychological impact of information.[11] We assume that if the investor pays more attention on the decision-making problem, it implies that he has a higher memory utility. An investor with larger m would have larger emotional responses to gains and losses. Intuitively, if the investor's m is higher, he will have more incentive to pay attention on the outcome of the investment as it has larger impact on his utility. However, here, we do not attempt to model attention endogenously. We ask what the relationship between attention and memory should be. We believe that the investment outcome will have higher impact on the utility of a more attentive investor. Take an extreme example that an investor is not attentive to the investment outcome at all (which is equivalent to m=0 in our model). In this case, the investor will have no incentive to forget a WPS. We measure attention using self-reported frequency of checking stock price, which is similar to the measure by Karlsson et al. (2009) based on number of account logins.

Because a DM chooses to forget if and only $(1 + \beta)m > 0.5\beta x$ (when faced with bad news), conditional on x, the DM who pays more attention to the decision-making problem is thus more likely to choose "forget" (when faced with bad news). This brings us to the following proposition.

Proposition 2. *The DM who pays more attention to decision-making is more likely to choose to "forget" when faced with bad news.*

Extension: Repeated game

We now assume that there are N rounds, and each round consists of three periods, like those described above. For simplicity, we assume that there are no links across rounds and that the DM's preferences are independent across rounds, i.e., the DM's choice to remember or forget in a given round has no impact on his choice in other rounds. According to our analysis above, in any given round, when there is good news in period 1, the DM will always choose to remember, and when there is bad news in period 1, the DM will choose to remember if and only if $(1 + \beta)m < 0.5\beta x$, i.e., if and only if $m < 0.5\beta x/(1 + \beta)$. Thus, in any given round, if the DM's choice in period 0 is correct, then his wealth at the end of this round is $2x$. If the DM's choice in period 0 turns out to be wrong, then the DM's wealth at the end of the round is x if $m < 0.5\beta x/(1 + \beta)$, and x with probability 0.5 and 0 with probability 0.5 if $m > 0.5\beta x/(1 + \beta)$. Thus, in any given round, the DM's end-of-round expected wealth will be $0.5 * 2x + 0.5 * x = 1.5x$ if $m < 0.5\beta x/(1 + \beta)$, and will be $0.5 * 2x + 0.5 * (0.5x + 0.5 * 0) = 1.25x$ if $m > 0.5\beta x/(1 + \beta)$. Intuitively, if the DM has a higher m, then he accumulates less

[7] In our model, good (bad) news refers to the good (bad) outcome that the payoff of the option chosen is high (low).

[8] An alternative approach to model memory is to follow the literature on self-signaling (see e.g., Bénabou and Tirole, 2004; Hong et al., 2019). The DM in period 1 may use observable actions to signal to DM in period 2 about the true state. While this is a very interesting question, our model abstracts away from this possibility. We assume that if the DM chooses to forget in period 1, in period 2, he cannot infer what is the true state. That is, when we say the DM forgets about bad news, we mean he totally forgets everything, including the existence of period 1.

[9] When the DM has a von Neumann–Morgenstern utility function u, assuming $u(0) = 0$, then the condition for forgetting is $m > 0.5\beta u(x)/(1 + \beta)$. Our main results still hold.

[10] If the decision maker chooses to remember (forget) the wrong chosen option, his choice will be consistent (inconsistent) with the reinforcement learning literature (e.g., Kaustia and Knüpfer, 2008; Strahilevitz et al., 2011) in finance. For investors who forget WPS, according to our model (see the extension: repeated game), they will be more likely to be driven out of the market in the long run, while those whose choice consistent with reinforcement learning will be more likely to survive in the market.

[11] They termed this as the "impact effect". Although their context is different from ours, it suggests that attention is a decision and linked with ones' utility.

wealth (in terms of expected wealth) in each round. Thus, the DM with higher m is more likely to be crowded out of the market.

More precisely, we assume that there is a unit mass of continuum of DMs and that each DM's m is independently drawn from a distribution F with support $[\underline{m}, \overline{m}]$ where $\underline{m}<0.5\beta x/(1+\beta)$ and $\overline{m} > 0.5\beta x/(1+\beta)$. Let the probability that m is greater than $0.5\beta x/(1+\beta)$ be α. At any round n, assume that a DM will quit the market at the end of the round if the DM's accumulated wealth up to the end of that round is strictly less than $n*x$ (we can imagine that the cost of participating in each round is x, and thus the total cost needed from round 1 to round n is $n*x$. This implies that the DM will quit the market if and only if the return is strictly less than the cost). For example, at the end of round 1, all DMs with m lower than $0.5\beta x/(1+\beta)$ will continue to stay in the market, 1/4 of DMs who have m higher than $0.5\beta x/(1+\beta)$ will quit the market (noting that for a DM with m higher than $0.5\beta x/(1+\beta)$, his wealth accumulated in the 1st round is $2x$ with probability 0.5, x with probability 0.25, and 0 with probability 1/4). More generally, it is easy to verify that at the end of each round, there is a positive probability that DMs with m higher than $0.5\beta x/(1+\beta)$ will quit the market while all DMs with m lower than $0.5\beta x/(1+\beta)$ will stay. In other words, as time goes by (i.e., as N becomes large), those with m higher than $0.5\beta x/(1+\beta)$ will be gradually driven out of the market. Noting that the DMs with m higher than $0.5\beta x/(1+\beta)$ are also those who choose to forget when faced with bad news and the DMs with m lower than $0.5\beta x/(1+\beta)$ are those choose to remember when having bad news, the selection of DMs across time exhibits the pattern wherein the DM who chooses to forget is more likely to be driven out of the market. Alternatively, we can state this result as follows:

Proposition 3. *DMs who have more experience (i.e., those who have stayed in the market for longer) are more likely to choose to "remember" when faced with bad news.*

3. Hypotheses and experimental design

3.1. Hypotheses

The simple theory leads us to have the following hypotheses:

Hypothesis 1. More experienced investors are more likely to remember WPS.

Hypothesis 2. Present biased investors are more likely to forget WPS.

Hypothesis 3. Investors who pay more attention to stock prices are more likely to forget WPS.

The intuition of Hypothesis 1 is that investors who forget WPS will be more likely to suffer loss in their future trading and hence more likely to be driven out of the market. Hence, in the long run, more experienced investors are those who are more likely to remember WPS. The intuition of Hypothesis 2 is that present biased investors will discount future utility (benefits of making better investment decisions) more heavily, hence focus more on current utility, and thus more likely to forget WPS. For Hypothesis 3, the intuition is that if the investor pays more attention on the decision-making problem, then he has a higher memory utility which is the utility by remembering the outcome. Based on our theory, a more attentive investor will have higher disutility when remembering the WPS, thus the investor who pays more attention is more likely to choose "forget" (when faced with bad news).

3.2. Experimental design

We conducted an online survey experiment in 2018 with 211 investors in Hong Kong.[12] The investors were recruited from an advertisement posted in a major newspaper in Hong Kong. They received a participation fee of HK$200 and an additional amount of money from a randomly drawn game in the survey.[13] Subjects were at least 25 years old.

In the online survey, we elicited subjects' memories about their best performing stock (BPS) and worst performing stock (WPS).[14] They also played a series of incentivized games including risk preference, time preference, and degree of strategic reasoning. They also answered questions about their years of investment experience in the stock market, and demographic information. For our purpose, we report the results of tasks and questions related to the focus of this paper.[15]

Memory recall on investment performance

We ask subjects the following two questions on WPS and BPS. In Q1, we ask subjects to recall the most profitable stock (BPS) in their past investment. In Q2, we ask subjects to recall the stock with the most losses (WPS).[16] For each question, the subjects choose to either input the stock code or choose "cannot remember." One mechanism that makes an investor unable to tell anything when asked about WPS is that although the investor forgot some bad experiences in his investment history, the investor is also aware of the fact that he forgot his bad experiences. That is, the investor does not remember the details about the bad experiences (say the strategies used in the experience, or the stock name involved in the experience, etc.), but he is aware of that he had the bad experience. So, when he is asked about WPS, he may say he cannot remember the WPS (in particular, the stock code of the WPS in our experiment).[17,18] For investors, the stock code represents good/bad outcome of their investment, and hence can be interpreted in model of memory such as the one we presented.[19] For Hong Kong investors, stock code is very

[12] Subjects were asked to upload 12 months of investment statements. Thus, we believe that the number of subjects is not "small" given the requirement. Nine subjects did not submit their investment statements. We admit that there is a potential selection bias that those willing to submit statements could be related to motivated memory.

[13] US$1 ≈ HK$7.78

[14] We didn't ask about BPS and WPS in their entire trading history of the 12 months of statement uploaded because (1) we are interested in their BPS and WPS in their entire investment history rather than in the 12 months periods, and (2) for a lot of subjects, we do not have information on their purchasing and selling price of the stocks, and thus not possible to determine the BPS and WPS.

[15] See online appendix B for the experimental instructions.

[16] One may concern that the memory elicitation is not incentivized and cannot be validated. We acknowledge this weakness. However, it seems very difficult, if not impossible, to validate with 100% accuracy on the responses of real-life investors because it is basically "impossible" to obtain actual investment records of investors across *all* investment companies globally. For this reason, we take an alternative approach to verify if the responses are consistent with the theoretical predictions on the three hypotheses. If investors are giving random answers, then we should not observe supportive evidence for the three hypotheses.

[17] We assume that the investors are sophisticated who are aware of their own motivated memory problem. This is a limitation of our model as there may be both naïve and sophisticated behavioral agents, and whether there are many sophisticated agents is an open question.

[18] It is plausible that a subject might disclose his BPS and choose "cannot remember" for his WPS even he remembers his WPS, because he wishes to maintain his image as a successful investor. Our identification of memory recall bias is via investigating the correlation between forgetting WPS and present bias. We do not expect to observe a correlation between forgetting WPS and present bias if the subjects are only driven by image concern.

[19] We implicitly assume that whenever an investor remembers/forgets the stock name then he remembers/forgets the corresponding outcome and vice

commonly used when communicating about their investments and it is the necessary information to enter when buying and selling stocks. Hence, stock codes are necessary component of the experiences. Instead of using stock symbol as in the USA, investors in Hong Kong use stock codes.[20]

One may wonder that for investors to be better at remembering the stock codes for BPS than for WPS, one only needs to make the assumption that recalling a good experience can better maintain one's positive emotional state, at the time of answering the survey, but it does not necessarily involve motivated memory as in Bénabou and Tirole (2002) or Brunnermeier and Parker (2005). Emotion state is indeed one of the factors of determining memory bias, which can be interpreted in terms of m in our model. However, there are other factors including effect of present bias, attention, and experience as we present in our model. In our experiment, we find that the latter factors matter and hence supporting the motivated memory hypothesis.

Time preference

We elicit the time preference using the following two tasks. In the first task, in a series of 10 choices, subjects choose between receiving HK$60 today versus HK$62 to HK$80 in 1 week. We use the first switch point, when the subject switches from receiving HK$60 today to the higher amount in 1 week, to calculate the corresponding discount rate (discount rate 1). The second task is the same as the first task except that subjects choose between receiving HK$60 in 1 week and receiving a higher amount in 2 weeks. A subject is classified as exhibiting present bias if the discount rate 1 is higher than the discount rate 2.

Attention

We measure investor's attention on the stock market by using their self-reported frequency of checking stock price on a scale of 1 (rarely) to 4 (multiple times a day).

4. Experimental results

4.1. Biased recall

Table 1 reports the summary statistics of memory recall patterns. Our first observation is that investors do not have perfect memories (Fig. 1). In particular, 45% of investors cannot remember their BPS, and 51% of investors cannot remember their WPS. Further, 35% of subjects forget both BPS and WPS, 39% remember both BPS and WPS, 16% remember BPS and forget WPS, and 10% forget BPS and remember WPS.

A number of interesting memory recall patterns can be observed from Table 2. The proportion forgetting WPS is 51% which is higher than the proportion forgetting BPS, and the difference is weakly significant with p-value equal to 0.08 under paired t-test. Note that forgetting WPS include those forget WPS and BPS, and forget WPS and remember BPS. Similarly, forgetting BPS include those forget WPS and BPS, and forget BPS and remember WPS. Thus, the comparison is based on whole sample which includes investors who have memory error (i.e., forget both WPS and BPS) and those without memory error (i.e., remember both WPS and BPS) instead of motivated memory. One may concern that the comparison is only marginally significant. Since we are interested on whether there is motivated memory in recalling BPS better than WPS, a better comparison should exclude those forget both WPS and BPS or remember both WPS and BPS.

Table 1
Summary statistics.

	Proportion
Forget BPS	0.45
Forget WPS	0.51
Forget Both BPS and WPS	0.35
Remember Both BPS and WPS	0.39
Forget BPS and Remember WPS	0.10
Remember BPS and Forget WPS	0.16

Conditional on subjects who cannot remember both WPS and BPS, 84% of subjects forget WPS, while 74% of subjects forget BPS, and the difference is significant with p-value equal to 0.05 under the two-sample proportion test. Conditional on subjects who cannot remember both WPS and BPS, and do not forget both WPS and BPS, 62% of subjects forget WPS while 38% forget BPS, the difference is significant with p-value equal to 0.01 under the two-sample proportion test.

The proportion of investors who forget WPS and remember BPS (16%) is higher than that of those who forget BPS and remember WPS (10%), the difference is significant with p-value equal to 0.06 under two-sample proportion test. Conditional on subjects cannot remember both WPS and BPS, 27% of subjects exhibit the bias of forgetting WPS and remember BPS, while 16% of subjects forget BPS and remember WPS, the difference is significant with p-value equal to 0.05 under the two sample under two-sample proportion test. Conditional on subjects who cannot remember both WPS and BPS, and do not forget both WPS and BPS, 62% forget WPS and remember BPS, while 38% forget BPS and remember WPS, the difference in proportion is significant with p-value equal to 0.01. In sum, we find that subjects are more likely to forget WPS than BPS.

Result 1. Investors are more likely to forget WPS than BPS.

4.2. Experience effect

The average number of years of experience in the stock market is 12.18 and the median is 10 years. We divide the subjects into two groups: those with years of experience less than the median as the less experienced group and those with equal or more than the median as the more experienced group. The less experienced group accounts for approximately 34% of the total sample.

Memory bias of less experienced investors and more experienced investors

We find that the less experienced group is more likely to forget WPS than to forget BPS. We find that 64% of the less experienced group forget WPS, whereas 50% of them forget BPS. The difference is significant, with p-value equal to 0.01 (Table 3). However, the more experienced group does not exhibit this bias.[21]

Further, the less experienced investors are also more likely to forget WPS and remember BPS than to remember WPS and forget

versa. This is indeed a strong assumption. The rationale that we make this assumption are two-folds. First, with this assumption, we can make our experiment design more simple and easier to understand as we can simply asking a subject whether he remembers the stock code of his BPS/WPS. In comparison, if we ask a subject whether he remembers the outcome or the strategy used in BPS or WPS, we may first need to clearly specify the meaning of "outcome" or "strategy" for the subject. Second, although in practice, remembering/forgetting a stock name is not equivalent to remembering/forgetting the corresponding outcome, we believe they are highly correlated.

[20] We ask stock code as it provides unique identification, and it is a common practice for Hong Kong investor to use the code. However, some subjects enter name of the company in the survey, we include these responses in our analysis.

[21] This also suggests that investors indeed exhibit memory recall bias and do not merely exhibit an aversion to revealing their WPS. Note that if investors exhibit an aversion to revealing their WPS, then more experienced investors would be more likely to forget their WPS than BPS, which is not observed.

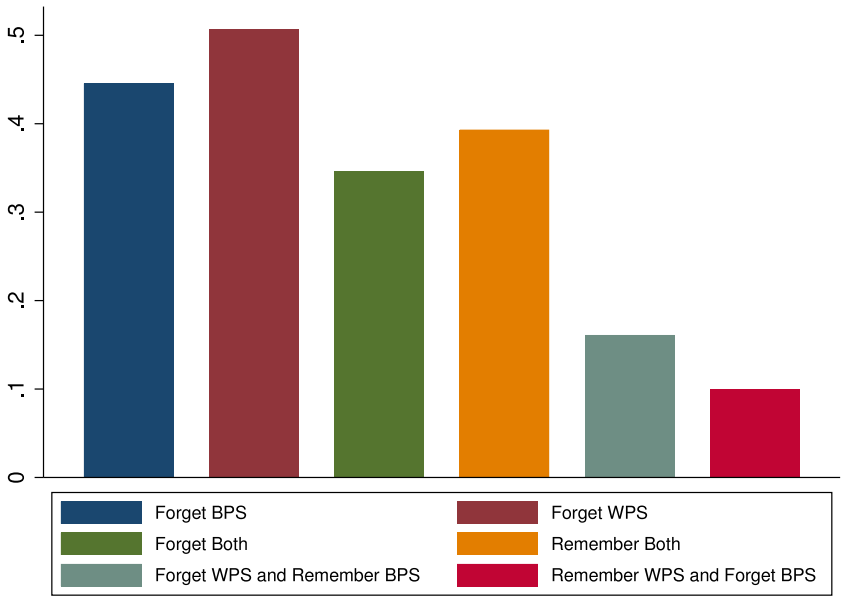

Fig. 1. Memory recall patterns.

Table 2
Comparisons of memory recall.

Proportion of forgetting	Worst performing stock (WPS)	Best performing stock (BPS)	Mean difference	*p*-value
Whole Sample	0.51	0.45	0.06	0.08*
Conditional on Cannot Remember both WPS and BPS	0.84	0.74	0.10	0.05**
Conditional on Do not Forget both WPS and BPS	0.25	0.15	0.09	0.05**
Conditional on Cannot Remember both WPS and BPS, and Do not Forget both WPS and BPS	0.62	0.38	0.24	0.01***
	Forget WPS and Remember BPS	Forget BPS and Remember WPS		
Whole Sample	0.16	0.10	0.06	0.06*
Conditional on Cannot Remember both WPS and BPS	0.27	0.16	0.10	0.05**
Conditional on Cannot Remember both WPS and BPS, and Do not Forget both WPS and BPS	0.62	0.38	0.24	0.01***

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

BPS (Table 3). Interestingly, this pattern is not observed for the more experienced group.

The more experienced group is more likely to remember both WPS and BPS than to forget both. In particular, 43% of more experienced investors remember both WPS and BPS, whereas 29% forget both WPS and BPS. The difference is significant with *p*-value equal to 0.01 under the two-sample test of proportions. In contrast, in the less experienced group, 46% do not recall either WPS or BPS, whereas 32% remember both WPS and BPS. The difference is not significant, with *p*-value equal to 0.09 under the two-sample test of proportions.

Comparison between less experienced investors and more experienced investors

Table 4 shows that the less experienced group is more likely than the more experienced group to forget WPS. In particular, 64% of investors in the less experienced group forget their WPS, compared to 44% of investors in the more experienced group.[22]

Table 3
Memory recall of less experienced and more experienced subjects.

Proportion of forgetting		Mean difference	*p*-value
Less experienced			
Forget WPS	Forget BPS		
0.64	0.50	0.14	0.01**
Forget WPS and Remember BPS	Remember WPS and Forget BPS		
0.18	0.04	0.14	0.01**
More experienced			
Forget WPS	Forget BPS		
0.44	0.42	0.02	0.63
Forget WPS and Remember BPS	Remember WPS and Forget BPS		
0.15	0.13	0.02	0.63

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

[22] We find a similar pattern when estimating the correlation between forgetting WPS and number of years of experience in stock market. In particular, there is a significant negative correlation between forget WPS and number of years of experience in the stock market, with correlation coefficient = −0.15 and *p*-value = 0.03. There is no significant correlation between forget BPS and number of years of experience in the stock market, with correlation coefficient=0.02 and *p*-value = 0.74. There is a significant negative correlation between forget WPS and BPS and number of years of experience in the stock market, with correlation coefficient=-0.17 and *p*-value = 0.01. There is no significant correlation between remember WPS and BPS and number of years of experience in the stock market, with correlation coefficient=0.09 and *p*-value = 0.21. There is no significant correlation between forget WPS and remember BPS and number of years of

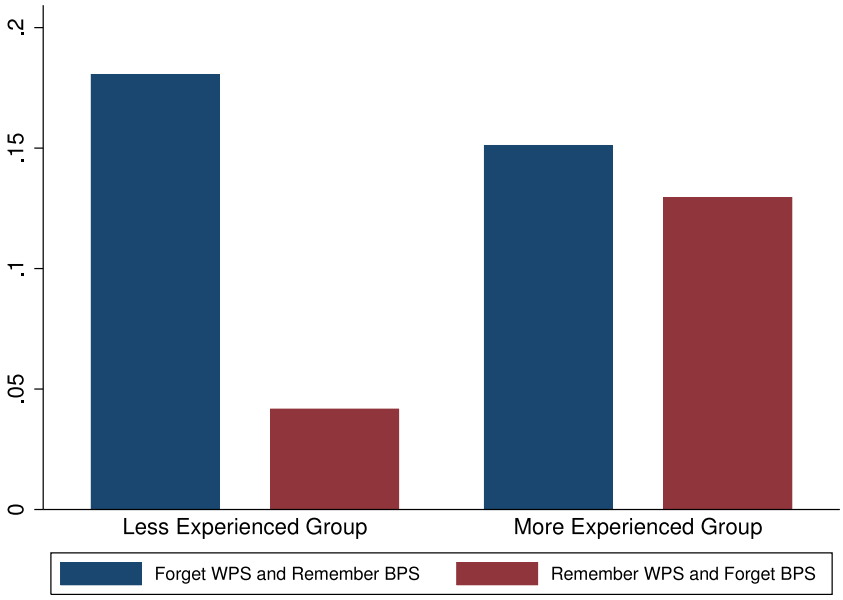

Fig. 2. Experience and memory recall bias.

Table 4
Comparison of memory recall between less experienced and more experienced investors.

	Less experienced	More experienced	Mean difference	*p*-value
Forget BPS	0.50	0.42	0.08	0.25
Forget WPS	0.64	0.44	0.20	0.01***
Forget WPS and BPS	0.46	0.29	0.17	0.01**
Remember WPS and BPS	0.32	0.43	−0.11	0.11
Forget WPS and Remember BPS	0.18	0.15	0.03	0.58
Remember WPS and Forget BPS	0.04	0.13	−0.09	0.04**

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

The difference in proportion is significant, with *p*-value equal to 0.01. The less experience investors are less likely to remember WPS and forget BPS than more experienced investors, and the difference is significant with *p*-value equal to 0.04 (see also Fig. 2).

There is no significant difference between the two groups on the proportion of investors who cannot recall BPS (Table 4). Taken together, this suggests that the difference in the memory recall of the two groups is mainly driven by the difference in recalling WPS rather than in recalling BPS.

Result 2. Less experienced investors are more likely than more experienced investors to forget WPS.

We find that 46% of the less experienced group forget both WPS and BPS, whereas 29% of the experienced group forget both WPS and BPS (Fig. 2). The difference is significant, with *p*-value equal to 0.01 under the two-sample test of proportions (Table 4). There is no significant difference between the two groups in terms of the proportions of investors who remember both WPS and BPS, or in terms of the proportions of investors who forget WPS and remember BPS.

Overall, the result suggests that less experienced investors are more likely than more experienced investors to exhibit the memory recall bias of forgetting WPS.

experience in the stock market, with correlation coefficient=0.02 and *p*-value = 0.74. There is no significant correlation between forget BPS and remember WPS and number of years of experience in the stock market, with correlation coefficient=0.10 and *p*-value = 0.14.

4.3. Present bias and memory recall bias

Column 1 of Table 5 reports the results of the marginal effect probit regression on forgetting WPS. We find that the coefficient of present bias is significantly positive, indicating that present biased investors are more likely to forget WPS. More specifically, present biased investors are 34.8% more likely to forget WPS. This is consistent with our model. The regression in columns 2 shows that present bias do not have significant effect (the coefficient is weakly significant) on forgetting BPS.

Result 3. Present biased investors are more likely to forget WPS.

4.4. Attention and memory recall bias

The coefficient of attention in column 1 of Table 5 is significantly positive, which implies that the investors who are more attentive are more likely to forget WPS, while attention is not significantly correlated with forgetting BPS as shown in the regression in column 2. Taken together, the regressions show that investors who pay more attention to stock prices are more likely to forget WPS but not BPS. This is consistent with the idea of myopic loss aversion (Benartzi and Thaler, 1995), which posits that when investors are given feedback more frequently, they suffer a higher loss in utility and are more likely to forget WPS. Our study is the first to identify the relationship between attention (see e.g., Sims, 2003; Kacperczyk et al., 2016; Karlsson et al., 2009; Barber and Odean, 2008; Peng and Xiong, 2006; Wang, 2017; Frydman and Wang, 2020) and memory recall bias.

Table 5
Determinants of memory recall bias.

	Dependent variables:	
	(1) Forget WPS	(2) Forget BPS
Present bias	0.348***	0.267*
	(0.113)	(0.144)
Attention	0.126***	0.038
	(0.034)	(0.032)
Loss averse	0.098	0.052
	(0.078)	(0.074)
Confidence	−0.026	−0.201
	(0.170)	(0.165)
Bounded rational	−0.004	−0.014
	(0.083)	(0.082)
Female	0.111	0.083
	(0.074)	(0.072)
Stock percent	−0.001	0.000
	(0.002)	(0.001)
Risk aversion	0.016	0.096
	(0.064)	(0.064)
Invest stock year	−0.005	−0.004
	(0.005)	(0.004)
Pseudo R-squared	0.11	0.05
Observations	204	204

Notes: This table reports the marginal effect estimations of probit regressions. Attention is the frequency of checking stock price on a scale of 1 (rarely) to 4 (multiple times a day). Loss averse is a dummy that equals 1 if the subject's degree of unhappiness of losing/winning HK$10,000 is higher than the degree of happiness of winning HK$10,000, and zero otherwise. Confidence is the degree of self-reported confidence that the return on investments in the stock market will be higher than the market return. Stock percent is the percentage of investment in the stock market over wealth. Risk aversion is the elicited degree of risk aversion. Bounded rational is a dummy that equals 1 if the subject submits more than 70 in the P beauty contest game, zero otherwise. *, **, and ***, denotes significance at 10%, 5%, and 1% levels, respectively.

Result 4. Investors who pay more attention to stock prices are more likely to forget WPS.

4.5. Memory recall bias and portfolio returns

We calculate the investors' monthly average portfolio returns. We use the sub-sample in which investors have no stock transactions in the sample period, allowing us to accurately estimate the portfolio's monthly returns.[23] The average monthly portfolio returns of those who can remember both WPS and BPS is 0.9%, which is significantly higher than that of those who do not remember both (−3.7%), with p-value = 0.01. The average monthly return of those who forget WPS (−3.3%) is significantly lower than that of those who can remember WPS (−0.2%), with p-value = 0.06. Excluding subjects who forget both WPS and BPS, the average monthly return of those who forget WPS (−4.3%) is significantly lower than that of those who can remember WPS (−0.2%), with p-value = 0.03.[24] Overall, the analysis shows that investors with better memory tend to have better investment performance, and investors' memory bias of forgetting WPS may lead to lower investment performance. In Bénabou and Tirole (2002), memory bias arises to overcome underinvestment problem. It is possible that the instrumental value of motivated beliefs may help improve investment performance in the long term, rather than only lowering it. For example, it may reduce the likelihood of limited stock market participation (Allen and Gale, 1994), and hence forgetting WPS can be potentially welfare improving in the long-run (Mehra and Prescott, 1985). We find that there is a significant negative correlation between forgetting WPS and percentage of wealth invested in the stock market, with correlation coefficient equals to −0.19, with p-value = 0.01.[25] Taken together, the results suggest that the net effect of memory bias of forgetting WPS seems to be negative, and it arises mainly due to the motivation to avoid loss in memory utility m rather than to improve performance or lessen the underinvestment problem.[26]

5. Discussions

We conduct a lab-in-the-field experiment to investigate the memory recall bias of real-life investors eliciting their memories about their BPS and WPS. Our study is the first to identify memory recall bias of real-life investors.

We have four main findings. First, investors are more likely to forget WPS than BPS. Second, less experienced investors are more likely to forget WPS than more experienced investors, while there is no difference on BPS. The effect of experience is consistent with the findings of List (2003) that more experienced traders of sports card do not exhibit this market anomaly. Third, present biased investors are more likely to forget WPS. Four, investors who pay more attention on stock prices are more likely to forget WPS. The findings on present bias, experience, and attention are consistent with our model.

Several interesting questions can be investigated in the future. First, to our knowledge, all existing studies on memory recall using experimental economics are not able to answer the question of when does the memory bias happens, it is thus an interesting question to study this question in the future. Second, our findings suggest that reminding investors of their historical investment records such as WPS can improve their welfare. Future studies can investigate the effect of such reminders. Third, it would be interesting to investigate the relationship between memory bias and stock market anomalies such as excessive trading and preference for lottery-like stocks.

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Compliance with ethical standards

This research received ethical approval by the Human Subjects Ethics Committee of City University of Hong Kong (application number H000790).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

23 To control for the effect of outlier values, we do not use the top 5% and bottom 5% observations.

24 The average monthly returns of those who forget BPS is −3.4%, which is weakly significantly different from those who can remember (−0.6%), with p-value = 0.09. Excluding subjects who forget both WPS and BPS, the average monthly return of those who forget BPS (−5.6%) is significantly lower than that of those who can remember BPS (−0.6%), with p-value = 0.03.

25 There is no significant correlation between forgetting BPS and percentage of wealth invested in the stock market, with correlation coefficient equals to −0.11, p-value = 0.12. There is a significant positive correlation between remembering both BPS and WPS and percentage of wealth invested in the stock market, with correlation coefficient equals to 0.15, with p-value = 0.03. There is a significant negative correlation between forgetting both BPS and WPS and percentage of wealth invested in the stock market, with correlation coefficient equals to −0.16, p-value = 0.03.

26 Note that the time period covered is relatively short. Future research may investigate the performance using longer time periods.

Data availability

The data for this study can be downloaded from https://doi.org/10.3886/E171021V1.

Online appendix

Two extensions on the theory and experimental instructions can be found online at https://doi.org/10.1016/j.jbef.2022.100760.

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