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Remembering past present biases

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A B S T R A C T

This study examines a potential link between present bias and reduced memory accuracy in intertemporal decision-making. In a classroom experiment with university students, participants made choices between smaller-sooner and larger-later rewards on two occasions. The second time included an immediate option, tempting present-biased participants to choose the immediate reward. During a third visit, participants were randomized into two groups and asked to recall their decisions from one of the previous visits. The results show that participants with present bias had lower memory accuracy than their time-consistent peers in situations involving immediate rewards. Regression analysis indicates that this reduced accuracy is consistent with motivated misremembering — in which individuals recall their past decisions as more virtuous than they actually were. Robustness checks reveal that time inconsistency is positively associated with lower memory accuracy in general, but present-biased participants exhibit clearly distinct patterns compared to their future-biased counterparts. These results are weighed against alternative explanations, notably the possibility of noisy cognition.

1. Introduction

Present bias, the tendency to disproportionately value immediate rewards over future benefits, is closely related to procrastination, the behavior of delaying tasks that involve effort or costs despite their potential long-term benefits. This bias is associated with negative outcomes across various domains, such as education (e.g., Kim & Seo, 2015), the labor market (e.g., Paserman, 2008), and health (e.g., Bradford, Courtemanche, Heutel, McAlvanah, & Ruhm, 2017). However, present bias is not inherently problematic if individuals are sophisticated, meaning they are aware of their bias and capable of mitigating it, for example, through the use of commitment devices (Cobb-Clark, Dahmann, Kamhöfer, & Schildberg-Hörisch, 2024; O'Donoghue & Rabin, 1999).

One possible route to such awareness is the ability to recall instances where one acted impulsively, driven by the allure of immediate rewards. Memory of past behavior may serve as a basis for recognizing one's own time-inconsistent tendencies and adjusting future decision-making accordingly. While introspection may also contribute to such awareness, the role of memory – particularly in forming self-perceptions – remains underexplored.

Theoretical models of decision-making include awareness as a factor in mitigating present bias (e.g., O'Donoghue & Rabin, 2001), but empirical evidence on whether individuals are aware of their own bias remains limited. Existing studies suggest that individuals may not recognize their tendency to favor immediate rewards (Augenblick & Rabin, 2019; Wong, 2008). We contribute to this literature by examining potential differences in memory accuracy between present-biased and time-consistent individuals. We hypothesize that present-biased individuals may recall their decisions as more favorable, particularly in situations involving immediate rewards, as they are motivated to maintain a positive self-image (though we also consider possible alternative explanations later). This process of 'motivated misremembering' has been documented in the literature, for instance, Carlson, Maréchal,

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Table 1
Example of the variables of main interest.

	Alex	Bobby	Charlie
First-visit switch	2	4	6
Second-visit switch	2	5	12
Remembered switch	2	4	7
Present-bias dummy	0	1	1
Degree of present bias	0	1	6
Misremembering dummy	0	1	1
Misremembering intensity	0	1	5

Oud, Fehr, and Crockett (2020) demonstrate that individuals tend to recall themselves as more generous than they actually were.

To test this hypothesis, we conducted an incentivized classroom experiment with university students. Participants made 12 choices between a smaller-sooner monetary reward and a larger-later one, across two different time frames. The smaller-sooner reward remained constant, while the larger-later reward increased with each choice. In tasks like this, participants typically choose the smaller-sooner reward initially, then switch to the larger-later reward as the task progresses.

During the first visit, participants chose between receiving different amounts of money in either 2 or 4 weeks. Two weeks later, they repeated the exercise, but this time they chose between receiving a reward immediately or delaying it for two weeks. Based on their choices, we classified participants as either time-consistent or time-inconsistent (with special regard to present bias). Time-consistent individuals made the same choice at the same decision point in both sessions. In contrast, present-biased individuals required greater compensation to delay receiving money in the second session compared to the first, indicating a later switch to the larger, delayed payment. This method allowed us to measure both the existence and strength of present bias. For example, if Alex switched at choice 2, Bobby at choice 4, and Charlie at choice 6 during the first visit, and their respective switches occurred at choices 2, 5, and 12 in the second visit, then Alex is time-consistent, while Bobby and Charlie are present-biased, with Charlie exhibiting a greater degree of present bias (see Table 1 for details).

A month later, we asked participants to recall their past decisions. They were randomly assigned to one of two groups: one group was asked to recall their choices from the first session, in which no immediate rewards were available, while the other group was asked to recall their decisions from the second session, where immediate rewards were present. Our main objective was to explore whether present-biased participants, who tend to act more impulsively when immediate rewards are available, exhibited directional inaccuracies in recalling their past actions, such as remembering them as less impulsive than they were. This design allowed us to investigate not only the presence of memory inaccuracies but also their direction. Following Carlson et al. (2020), we refer to such directional memory inaccuracy as motivated misremembering.

We assessed both the existence and extent of motivated misremembering by calculating the difference between each participant's recalled and actual switching points. If a participant recalled switching to the larger reward at an earlier decision point than they actually did, this could be consistent with motivated misremembering. Returning to our earlier example (see Table 1 for details), suppose Alex, Bobby, and Charlie were tasked with recalling their decisions from the second visit. They report remembering that they switched to the larger-later reward at decision points 2, 4, and 7, respectively. Alex recalls his choices accurately, while Bobby and Charlie exhibit motivated misremembering, as they remember switching earlier (indicating a willingness to accept less compensation for the additional two-week wait) than they actually did. Furthermore, the larger discrepancy between Charlie's recalled and actual decision indicates that his motivated misremembering is more intense.

The literature on motivated memory (Amelio & Zimmermann, 2023) and motivated belief (Bénabou, 2015) suggests that self-serving biases and concerns about self-image may lead individuals to recall their actions as more virtuous than they actually were. Therefore, we hypothesize that present-biased individuals may exhibit lower recall accuracy for decisions made during the second visit compared to time-consistent counterparts, potentially due to self-serving biases, though other factors could also contribute. This discrepancy is expected to arise during the second visit, where immediate rewards may trigger more impulsive decisions in present-biased participants, leading to recall patterns that could reflect either motivational factors or non-motivated mechanisms.

Returning to our earlier example (illustrated in Table 1), we hypothesize that if Alex, Bobby, and Charlie were asked to recall their choices from the second visit, Alex (being time-consistent) would perform better than both Bobby and Charlie. Furthermore, Charlie – who exhibits a greater degree of present bias – would perform worse in the recall exercise than Bobby.

Two related studies provide context for our research. Sial, Sydnor, and Taubinsky (2023) examine the relationship between biased memories and self-control in the context of gym attendance. They find that individuals with more biased memories tend to be more naive about their time inconsistency, but not more time-inconsistent themselves, suggesting no connection between present bias and memory bias. Conversely, Chew, Huang, and Zhao (2020) report that individuals who recall their past performance on a cognitive task more favorably also tend to exhibit greater present bias. Taken together, these findings highlight the ambiguity in the existing evidence on the relationship between present bias and memory accuracy, indicating the need for further investigation. We contribute to this research by focusing directly on intertemporal choice, a setting that allows us to both identify the presence of present bias and assess recall accuracy in decisions that explicitly contrast smaller-sooner versus larger-later rewards. This approach enables us to investigate whether motivated misremembering may serve as a potential mechanism linking present bias to its negative consequences, specifically, by reducing individuals' awareness of their own impulsive behavior and, in turn, their motivation to address it.

Despite differences in experimental design, our findings align with those of Chew et al. (2020). We find that approximately one-third of participants exhibit present bias. These individuals appear more likely to misremember their past choices when those choices involved immediate rewards. In particular, present-biased participants tend to recall having acted more patiently than they actually did, a pattern that is consistent with (but not exclusive to) motivated misremembering. This tendency emerges only in contexts involving immediate rewards; when participants recalled choices made in the absence of immediate temptation, no such bias in memory was observed.

Moreover, we observe that the degree of present bias is positively associated with both the likelihood and intensity of directional misremembering. Participants with stronger present bias appear to misremember more substantially, showing a larger discrepancy between their actual and remembered choices, consistent with motivational processes. These associations are statistically significant during the second visit, when immediate rewards were available, but not during the first visit, when both outcomes lay in the future.

Importantly, our analysis shows that these patterns are specific to present-biased individuals. Future-biased participants exhibit different misremembering patterns: they display lower memory accuracy when recalling decisions made in the absence of immediate temptation, and their errors are not consistent with the same directional bias observed in present-biased individuals. The selective occurrence of motivated misremembering in present-biased individuals – only in situations involving immediate rewards – suggests that the effect is not merely due to time-inconsistent individuals having poorer memory in general, but rather reflects a targeted, self-serving distortion of memory.

The rest of the study is structured as follows: Section 2 describes the data collection process and the experimental design. Section 3 presents the findings. In Section 4, we discuss our findings and provide additional analysis to address potential confounders. Section 5 concludes.

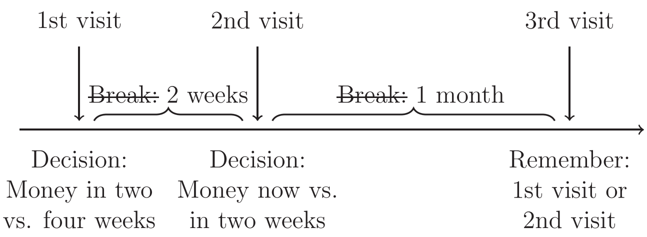


Fig. 1. Timeline of the experiments.

2. Experimental design and data collection

The participants were students from the *Macroeconomics* course at Corvinus University of Budapest, which is a core course in the Business Administration and Management bachelor's program. The course took place during the spring semester of the 2023/2024 academic year. A total of 388 students were enrolled in the course across 13 classrooms, forming the initial pool of participants.

To measure present bias and memory, we visited the classrooms three times, as shown in Fig. 1. During the first visit, we assessed intertemporal preferences with both dates in the experimental task set in the future — specifically 2 and 4 weeks ahead. Two weeks later, during the second visit, the earlier date involved the present, providing a different context and enabling us to assess whether participants exhibited present bias. According to the $\beta - \delta$ model (Laibson, 1997), the data from the first visit allowed us to calculate the long-term discount rate (δ), while the data from the second visit, combined with this rate, facilitated the evaluation of time consistency (β). The third visit, conducted one month after the second, aimed to evaluate how accurately participants remembered their earlier decisions. Although we did not announce the third visit during the first session, we informed students during the first visit that we would return for the second visit to handle payments. None of the visits coincided with holidays for any of the groups.

2.1. First visit

Our first classroom visits occurred during the second week of classes, from February 19 to 23, 2024. We entered at the start of each class. Instruction sheets were distributed to students who chose to participate, and the instructions were also read aloud to ensure clarity. Participation was explicitly stated to be voluntary, with students free to withdraw at any time. The instructions included a brief overview of the intertemporal choices involved (e.g., HUF 10,000 in two weeks or a higher amount in four weeks) and clarified that 10% of participants, selected at random, would receive vouchers redeemable at various shops and major chains based on their choices. The anonymity of the experiment was also emphasized. The sheet concluded with a QR code and a URL directing participants to an online platform for submitting their responses via laptop or smartphone. The questionnaire was programmed using Qualtrics.[2]

Upon accessing the online platform, participants encountered 12 choices. For the first choice, they had to decide between receiving HUF 10,000 (approximately 25 EUR at the time of the experiment) in two weeks or HUF 10,000 in four weeks. In subsequent choices, the later amount increased incrementally. Specifically, the choices were structured as follows: HUF 10,000 in two weeks versus HUF X in four weeks, where the values of X increased sequentially as follows: 10,000; 10,200; 10,400; 10,600; 10,800; 11,000; 11,300; 11,600; 11,900; 12,400; 12,800; and 13,500.[3]

We expected participants to: (i) choose to receive HUF 10,000 sooner rather than the same amount later in choice 1; and (ii) choose to receive HUF 13,500 later rather than HUF 10,000 sooner, given the substantially higher payment (equivalent to an annual compounded interest rate of 232.2%). The choice at which participants switched to the later-larger amount reflects the compensation they required to delay gratification by an additional two weeks. This serves as a proxy for their intertemporal preferences. For instance, if Participant A switched to the later-larger payment in choice 2 (opting for HUF 10,200 in four weeks instead of HUF 10,000 in two weeks), while Participant B switched only in choice 12 (opting for HUF 13,500 in four weeks instead of HUF 10,000 in two weeks), then Participant A required less compensation to wait the additional two weeks. This suggests that Participant A discounts the future less than Participant B.

Some remarks are warranted. First, the method we use to elicit time preferences belongs to the multiple price list methods, which are widely used. One potential issue with this method is that participants may switch multiple times, leading to inconsistent choices (Cohen, Ericson, Laibson, & White, 2020). Fortunately, we observed a very low rate of inconsistent choices due to multiple switches: 5.81% during the first visit and 0.65% during the second visit. Second, we used vouchers to incentivize choices because they were logistically simpler to handle than cash. Moreover, the vouchers are accepted in most major shops and chains, effectively functioning as money. Third, we opted for the Between-Subjects Random Incentive System (BRIS), which involves paying only a fraction of participants (10% in our case). The alternative would have been to pay all participants a tenfold lower amount given our budget, resulting in a maximum of 3.5 EUR per participant, which we deemed insufficient as an incentive. Due to the random nature of BRIS, each participant plays with high stakes at the time of decision-making, which we conjecture encourages them to take their decisions more seriously.[4]

After participants completed their choices, we gathered information about their backgrounds. This included their gender, proxies for family background (such as their mother's highest education level and their self-reported position on a social ladder), their math grade from the previous semester (used as a proxy for cognitive abilities), and their trust, risk, and time preferences.

2.2. Second visit

We revisited the classrooms two weeks later (March 4–8, 2024). We explained that our purpose was to conduct the draw to determine the 10% of students who would be paid according to the choices they had made two weeks earlier. Before proceeding with the draw, though, we offered participants the opportunity to reconsider their previous choices. The amounts available for selection were identical to those two weeks prior; however, since two weeks had passed, these amounts could now be received either immediately or two weeks later (instead of in two or four weeks).[5]

After the decisions were finalized, we conducted the random draw. Students who selected immediate payment received their vouchers on the spot. For those who opted for delayed payment, we placed the

[2] Appendix A contains the instructions for the first visit.

[3] The first increments were HUF 200 (approximately 0.5 EUR), while later choices involved larger increases. This approach was informed by prior experiments with Hungarian participants (Horn & Kiss, 2020; Horn, Kiss, & Lénárd, 2022), which revealed that students (not those in the current study) were often willing to wait even for minimal compensation, leading to a clustering of decisions at the lower end. To capture intertemporal preferences more precisely in this range, we used a finer grid.

[4] Brañas-Garza, Jorrat, Espín, and Sánchez (2023) provide evidence that using BRIS does not lead to different findings in intertemporal tasks compared to paying all participants.

[5] Appendix A provides the instructions given to participants during the second visit.

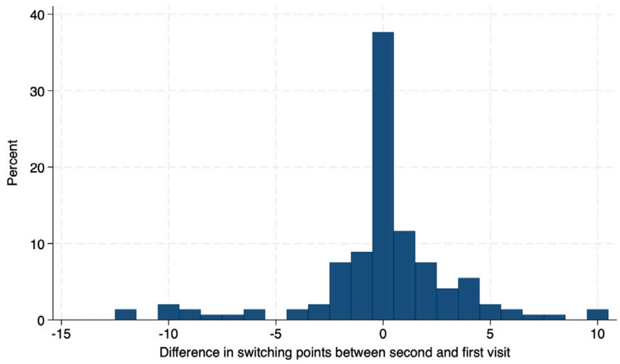


Fig. 2. Distribution of differences in switching points among all participants (N = 146)

vouchers in sealed envelopes and returned two weeks later to distribute them.

Choices made during our first and second visits enable us to categorize students based on their time consistency. Students who selected the same switching points on both occasions are classified as time-consistent, represented by the bar at zero in Fig. 2.[6] Participants who, during the second visit – when immediate payment was an option – chose a later switching point than during the first visit are considered present-biased (or, more neutrally, present-focused). These participants are represented to the right of the bar at zero in Fig. 2. A later switching point indicates that they require greater compensation to delay gratification by an additional two weeks when immediate payment is an option, reflecting a stronger preference for immediate rewards. Conversely, participants who selected an earlier switching point during the second visit demonstrate a lower required compensation for waiting. In Fig. 2, these participants are to the left of the bar at zero, indicating future bias (Takeuchi, 2011).

Of the participants, 37.67% are time-consistent, exhibiting identical switching points during the first and second visits. Additionally, 34.93% require higher compensation for an additional two weeks of waiting during the second visit, consistent with present bias.[7] In contrast, 27.40% of participants are future-biased, willing to wait an additional two weeks for less compensation when the present is involved compared to when both dates occur in the future.

While the previous definition of present bias is binary, its intensity may also be relevant. Intensity is calculated as the difference in switching points between the first and second visits (see Table C.6 in Appendix C). For one-third of present-biased participants, the difference in switching points between visits is only one, while for another third, the difference exceeds three. At the extreme, approximately 12% of participants exhibit a switching point at least five units higher during the second visit compared to the first, indicating a pronounced present bias.

In our analysis, we consider both definitions of present bias: the binary definition and the one accounting for its intensity.[8] Our primary focus is on how well present-biased participants recall their choices during the second visit, which requires a baseline group for comparison. Our main approach uses time-consistent participants as the benchmark, providing the cleanest comparison. Additionally, we complement this by comparing present-biased participants to all other participants, including future-biased and time-consistent individuals.[9]

As pre-registered, we excluded participants who made inconsistent choices by switching multiple times during either the first or second visit because multiple switches confound the definition of a single switching point. There were 9 such inconsistent participants during the first visit and 1 during the second visit.[10]

2.3. Third visit

Six weeks later (15–19 April 2024), we returned to the classrooms. Participants received sheets with brief instructions explaining that they were now tasked with recalling their previous choices. The recall process involved accessing the same platform with the same decisions; however, we clarified that we were not interested in how they would currently choose but instructed them to recall their earlier choices. Participants were randomly assigned to recall choices from either their first or second visits. To incentivize accurate recall, 10% of participants were randomly selected, and those who correctly remembered at least 10 out of 12 choices received HUF 5,000 (approximately 12.5 EUR at the time of the experiment).[11]

One-third of the participants were tasked with recalling choices from the first visit (Treatment 0), while the remaining participants were asked to recall choices from the second visit (Treatment 1). Since assignment to treatments was random, any differences in how well participants remembered earlier choices can be interpreted as revealing causal relationships. However, as present bias itself was not exogenously manipulated, we refrain from interpreting the results in a causal manner.[12] Appendix B confirms that the randomization was successful, as no statistically significant differences were found in the participants' background characteristics measured during the first visit.

2.4. Hypotheses

We pre-registered our study to explore potential differences in how present-biased participants recall their choices from the second visit compared to their time-consistent counterparts.[13] We aimed to examine whether they may exhibit patterns of recalling having chosen delayed rewards more frequently, potentially to favor a positive self-image. More specifically, we assessed whether participants remember switching to later-larger rewards at an earlier decision point (Y) than they actually did (X) during the second visit, focusing on those who did not switch more than once. Our primary dependent variable is a dummy (1 if $Y<X$), representing directional misremembering in a way that appears more favorable during the second visit. We hypothesize that present-biased participants may be more likely to exhibit such directional misremembering than their non-present-biased peers, potentially due to motivational factors.

[6] Fig. 2 includes participants for whom we have decision data from all three visits. Participants who made multiple switches in the intertemporal choice task were excluded.

[7] The share of present-biased participants in our sample aligns with findings from other studies: 35.6% in Horn and Kiss (2020), 32.8% in Horn et al. (2022), and 36% in Meier and Sprenger (2010).

[8] We pre-registered only the binary measure of present bias; therefore, our analysis using the intensity measure is exploratory.

[9] In our pre-registration, we did not clearly specify the comparison group. Consequently, we perform the analysis using both a narrow and a broad baseline group.

[10] Choice inconsistency is weakly and negatively correlated with mathematical abilities, with a correlation coefficient of -0.153 and a p-value of 0.058.

[11] Appendix A provides the instructions given to participants during the third visit.

[12] During the experiment's design phase, we considered using the recall of choices from the first visit as a benchmark for memory accuracy. This approach aimed to distinguish two potential sources of misremembering: (i) an inability to remember the decision and (ii) misremembering the decision due to motivated memory. The first source, (i), can be assessed through decisions made during the first visit, serving as a control. However, exploring the second source, (ii), requires recalling decisions from the second visit. We decided to assign only one-third of participants to the control group because our primary focus was on patterns potentially related to motivated memory, though other mechanisms may contribute.

[13] Pre-registration is available at https://aspredicted.org/r44b-gbnb.pdf

Table 2
Average correct memories of earlier choices.

		Present-biased (1)	Time-consistent (2)	Not present-biased (3)	Future-biased (4)	Wilcoxon rank-sum test (1) vs (2)	(1) vs (3)	(1) vs (4)
Average of correctly remembered choices during	First visit	11.06	11.84	11.52	10.75			
	95% CI	(10.32 11.80)	(11.66 12.02)	(11.20 11.84)	(9.88 11.61)	0.006	0.145	0.235
	N	17	19	27	8			
	Second visit	10.58	11.2	11.18	11.15			
	95% CI	(9.94 11.22)	(10.67 11.73)	(10.83 11.53)	(10.71 11.59)	0.027	0.042	0.280
	N	31	30	50	20			

Note: Observations without switching points are excluded.

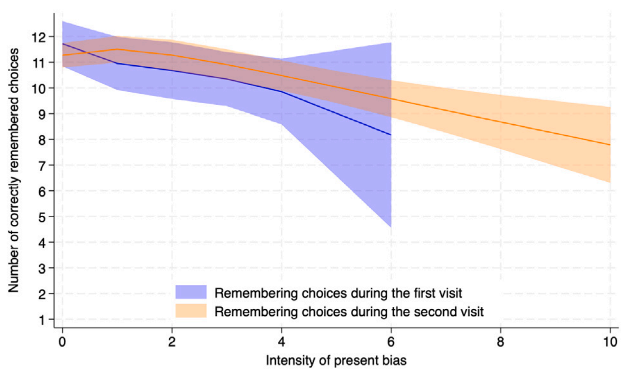


Fig. 3. Fractional polynomial plot showing the relationship between the average number of correctly recalled earlier choices and the intensity of present bias, with 95% confidence interval (all participants included, $N = 146$)

In the pre-registration, we also considered that not only the occurrence of directional misremembering (potentially due to motivational factors) but also its intensity could provide valuable insights. To capture this, we measured the distance between the remembered and actual switching points. Our secondary dependent variable, the intensity of motivated misremembering, is calculated as $X - Y$. Drawing on the literature on motivated memory, we hypothesize that greater intensity of directional misremembering is more strongly associated with present bias, although non-motivational processes may also contribute.

Table 1 uses the example from the Introduction to illustrate how our main variables are calculated, with the remembered switch referring to choices made during the second visit. Our pre-registered hypothesis stated that present bias is associated with both the occurrence and intensity of directional misremembering, potentially reflecting motivational processes. Specifically, we hypothesized that being present-biased is positively correlated with both measures of directional misremembering. That is, the Alexes among our participants are less likely to misremember – and to do so with lower intensity – than the Bobbys and Charlies in our sample. Additionally, we conjecture that the *degree* of present bias is also positively associated with these measures, consistent with motivational processes but warranting consideration of alternatives.. That is, the Charlies are more likely to misremember – and do so with greater intensity – than the Bobbys and Alexes.

2.5. Data and descriptive statistics

A total of 330, 297, and 224 participants responded to our questions during the first, second, and third visits, respectively. Of these, 155 participated in all three sessions. During the data cleaning process, we omitted 9 observations where individuals had more than one switching point, resulting in a main sample of 146 participants.

As shown in Appendix C.1, 9 participants did not switch during the first visit, and 18 did not switch during the second visit. This indicates that even substantial compensation – equivalent to over 200% annual interest – was insufficient to persuade them to wait an additional two weeks, reflecting a very high individual discount rate. Since our analysis is based on switching behavior, we excluded these individuals from the analysis.[14]

Table 2 summarizes the average number of correctly remembered choices from the first and second visits. Overall, participants exhibited strong recall of their earlier decisions, with average scores exceeding 10.5 out of 12 across all groups. We hypothesized that present-biased participants may exhibit lower recall accuracy during the second visit, potentially due to motivated misremembering. The descriptive statistics are consistent with this pattern: present-biased participants recalled fewer earlier choices from the second visit compared to both time-consistent participants alone and all non-present-biased participants (including future-biased and time-consistent individuals). This difference is statistically significant at the 5% level when either time-consistent participants or all non-present-biased participants are used as the comparison group. However, when compared to future-biased individuals, who correctly remembered more earlier choices on average, the difference between the two groups was not statistically significant at the 5% level, highlighting potential differences in memory patterns across bias types that may warrant further exploration.

Participants in all groups recalled choices from the first visit more accurately, on average, than those from the second visit, despite the first visit occurring two weeks earlier. This pattern may indicate that the presence of an immediate reward is associated with lower memory accuracy (though other factors could also contribute). Moreover, present-biased individuals exhibited significantly lower memory accuracy, even when recalling choices from the first visit. However, when time-consistent and future-biased individuals are pooled, the difference between this combined group and present-biased individuals is no longer statistically significant. Additionally, when compared to future-biased individuals alone, the difference between present-biased and future-biased participants was not significant in either of the visits, suggesting varied patterns that may not align solely with motivational mechanisms.

Fig. 3 illustrates the relationship between the average number of correctly remembered choices and the intensity of present bias. To account for potential non-linearities, we employ fractional polynomials. The figure indicates a negative relationship: as the intensity of present bias increases, recall accuracy for earlier choices appears to decline. Among participants asked to recall choices from the second visit, no significant difference is observed at low levels of present bias compared to time-consistent participants (those with an intensity level of 0). However, inaccuracies become more pronounced as the intensity of present bias increases, though this could involve non-motivational factors as well.

Overall, measured with a dummy variable or with intensity, participants exhibiting present bias tend to show lower accuracy in recalling

[14] Table C.7 in the Appendix replicates the analysis from Table 2, this time including non-switching individuals. The results of the statistical tests remain unchanged across all comparisons, except for the comparison between present-biased and non-present-biased participants, which becomes insignificant at the 5% level.

Table 3
OLS regressions regarding the relationship between present bias (occurrence and intensity) and directional misremembering (potentially motivated). Future-biased individuals and those who did not switch during at least one of the visits were excluded.

	First Visit		Second Visit		First Visit		Second Visit	
	Dummy	Intensity	Dummy	Intensity	Dummy	Intensity	Dummy	Intensity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Present Bias Dummy	−0.158	−0.158	0.392**	0.491				
	(0.087)	(0.087)	(0.122)	(0.499)				
Present Bias Intensity					−0.046	−0.046	0.098**	0.418**
					(0.026)	(0.026)	(0.020)	(0.125)
Constant	0.158	0.158	0.286**	0.929*	0.150	0.150	0.337**	0.527
	(0.087)	(0.087)	(0.087)	(0.388)	(0.083)	(0.083)	(0.075)	(0.306)
Observations	26	26	59	59	26	26	59	59
R^2	0.048	0.048	0.153	0.017	0.040	0.040	0.188	0.242

earlier decisions made during both the first and second visits, a pattern consistent with potential motivational effects but also possibly reflecting confounders such as noisy cognition.

3. Findings

The descriptive statistics suggest a potential association between present bias and lower accuracy in recalling earlier choices, consistent with our pre-registered hypothesis. Specifically, the hypothesis posits that present-biased participants may overreport choosing delayed rewards. We therefore tested whether they tend to recall switching to later-larger rewards earlier than they actually did – a pattern consistent with motivated misremembering – relative to their peers.

To enable a clear comparison, we exclude future-biased participants at this stage and designate time-consistent participants as the baseline group. Furthermore, we narrowed our sample to those who either did not misremember or misremembered in the hypothesized direction, reducing the sample size to $n = 85$. For the first visit, 11.5% of the sample showed directional misremembering consistent with recalling more delayed choices, while for the second visit, this proportion increased to 49.2%, potentially reflecting motivated processes (or other factors like cognitive noise). As mentioned earlier, our pre-registration included a directional hypothesis regarding motivated misremembering, but did not clearly specify the comparison group. In Section 4, we conduct extensive robustness checks, including cases of non-motivated misremembering and analyses involving future-biased individuals.

Let $SP1$, $SP2$, and SPR denote the switching points during the first, second, and third visits, respectively, where 'R' stands for 'remembering'. We focus exclusively on choices involving a single switch. As pre-registered, we define two dimensions of motivated misremembering: the intensive and extensive margins. To capture this, we introduced a dummy variable for motivated misremembering, which is assigned a value of 1 if the participant recalls switching to the later-larger reward earlier than they actually did. This implies that the participant remembers accepting a lower compensation for the two-week delay than they actually did, a pattern consistent with recalling more future-oriented choices, a manifestation of motivated misremembering, but potentially influenced by non-motivational factors as well. Consequently, this dummy variable equals 1 if $SP1 > SPR$ (for decisions remembered from the first visit) or $SP2 > SPR$ (for decisions remembered from the second visit) and 0 if the switching points are identical. Cases where participants remember being less virtuous than they actually were are excluded at this stage (but considered in Section 4), as our theoretical focus is on directional misremembering consistent with positive self-image, though this choice limits the exploration of other potential memory patterns.

To capture the intensity of motivated misremembering, we measure the number of decisions by which a participant's actual switching point exceeds their remembered one. Accordingly, our secondary dependent variables are $SP1-SPR$ and $SP2-SPR$, corresponding to decisions remembered from the first and second visits, respectively. The analysis is restricted to cases where these differences are non-negative.

Fisher's exact test reveals no significant relationship between the motivated misremembering dummy and being present-biased when remembering the first visit (p-value = 0.540). In contrast, the same test detects a significant association for remembering the second visit (p-value = 0.004). Similarly, when examining the pairwise correlation between the intensity of motivated misremembering and the intensity of present bias, no significant relationship is found during the first visit (correlation coefficient = −0.199, p-value = 0.330). However, a significant association emerges during the second visit (correlation coefficient = 0.492, p-value < 0.001).[15]

These findings suggest that present bias is associated with lower accuracy in recalling earlier choices, particularly when those choices involve immediate rewards. This pattern is consistent with participants potentially adjusting their memories to favor a positive self-image in situations where resisting the temptation of immediate gratification is particularly challenging.

To validate these findings, we present a regression analysis. Although our hypotheses focus on the recall of decisions during the second visit, for completeness, Table 3 reports the recall of decisions made during both visits. The table presents the results of OLS regressions, where the dependent variables are the motivated misremembering *dummy* (columns (1), (3), (5), and (7)) and the motivated misremembering *intensity* (columns (2), (4), (6), and (8)). The primary explanatory variable in the first four specifications is the present bias dummy, while in the last four it is the present bias intensity.

We find no significant association between present bias and the presence or intensity of directional misremembering during the first visit. However, consistent with our hypothesis, a significant positive relationship emerges during the second visit when considering the occurrence of directional misremembering: present-biased participants are nearly 40% more likely to exhibit this pattern compared to their time-consistent peers, potentially due to motivational factors. When using the intensity of directional misremembering as the dependent variable, the coefficient remains positive but does not reach statistical significance.[16]

Table C.9 in Appendix C.5 presents regression results using a dummy variable for motivated misremembering, while controlling for participants' observable characteristics (gender, mother's education,

[15] These values correspond to our database being restricted according to the pre-registration. In the full sample, the p-values from Fisher's exact test change to 0.125 and 0.043, respectively. Regarding the pairwise correlations, the correlation coefficient is −0.604 for the first and 0.503 for the second, both statistically significant at the 1% level.

[16] The coefficient of the *Present Bias Dummy* for the first visit is the same when we consider either the occurrence (*Dummy*) or the intensity (*Intensity*) of directional misremembering because, during the first visit, all participants who misremembered did so by exactly one unit.

self-assessed social status, math grades as a proxy for cognitive ability, trust, and risk attitudes). A dummy for data collection during the second visit suggests a higher likelihood of directional misremembering at that time. The present bias dummy is also significant, indicating that present-biased participants are more prone to this pattern, potentially due to motivational processes. Furthermore, an interaction term suggests that the association with present bias is stronger for the second visit, consistent with (but not exclusive to) motivational effects. These findings also hold when using the intensity of present bias as the main explanatory variable.[17]

Turning to specifications (5)–(8) in Table 3, and consistent with the previous findings, no significant association is observed between the intensity of present bias and directional misremembering (measured either as a dummy variable or by intensity) during the first visit. However, during the second visit, the relationship becomes positive and significant, consistent with our hypothesis. Specifically, a one-unit increase in present bias is associated with a nearly 10% higher likelihood of directional misremembering, potentially reflecting motivational factors. Moreover, greater present bias intensity corresponds to a significantly higher intensity of directional misremembering, potentially consistent with motivational processes.

Table C.10 in Appendix C.6 provides regression results where the dependent variable is the intensity of motivated misremembering, including additional control variables. The results suggest that directional misremembering intensity is higher during the second visit. While the present bias dummy is not significant in these regressions across all specifications, the intensity of present bias as the main explanatory variable yields a significant positive coefficient, consistent with potential motivational effects. This suggests that participants with greater present bias exhibit more intense directional misremembering, with the effect primarily observed during the second visit, potentially driven by motivational factors.[18] Notably, none of the control variables are statistically significant in any of the specifications.

4. Discussion

In this section, we conduct additional analyses to better understand the relationship between present bias and motivated misremembering. While our pre-registered hypothesis focused on this link, a broader investigation is needed to assess whether the observed results might be driven by confounding factors.

A key concern is that time-inconsistent intertemporal choices may generally correlate with lower memory accuracy. If so, our findings could merely reflect that present-biased individuals tend to misremember more often — regardless of any ego-protecting or self-enhancing motives.

To address this, we include future-biased participants as an additional control group. If time inconsistency alone explains memory errors, future-biased individuals should show misremembering patterns similar to present-biased ones.

The results of these analyses are presented in Table 4, which contains three panels based on the type of misremembering. The top panel, *Directional Misremembering Aligned with Motivational Factors*, captures cases where participants recall having switched to the larger-later reward earlier than they actually did. For present-biased individuals, who tend to prefer immediate rewards, this may reflect an ego-protective distortion.

Future-biased individuals, by contrast, may overvalue delayed rewards even when immediate ones are available, leading them to switch too early. As a result, they may be motivated to recall having switched later than they actually did, leading to errors in the opposite direction. Such errors are shown in the middle panel, labeled as *Directional Misremembering Not Aligned with Motivational Factors*, since for present-biased individuals there is no motivation to make such errors — although for future-biased individuals, such distortions may still be motivated. The bottom panel, *All Misremembering*, includes all errors, regardless of direction or motivation.

We examine each visit separately, as our hypothesis concerns misremembering during the second visit when immediate rewards were present. For each type of misremembering, we analyze both extensive and intensive margins: *Dummy* regressions indicate whether misremembering occurred, while *Intensity* regressions measure its magnitude.

Time-consistent participants are the baseline. In every specification we include both indicators (dummies) and intensity measures for present and future bias. Each panel reports eight columns: four for the first visit and four for the second. Within each visit, columns labeled ‘Dummy’ use a binary dependent variable (whether misremembering occurred), while columns labeled ‘Intensity’ use a continuous dependent variable (the magnitude of misremembering). ‘Present Bias Intensity’ is positive only for present-biased participants (zero otherwise); ‘Future Bias Intensity’ is defined analogously.

Each panel ends with a Wald test comparing the coefficients for present and future bias. For example, in the first specification of the top panel, a p-value of < 0.001 indicates that the coefficient -0.158^{*} differs significantly from 0.556^{***}.

The top panel shows that present-biased individuals do not exhibit significantly more directional misremembering aligned with motivational factors than time-consistent participants during the first visit. In fact, they appear slightly more accurate. In contrast, future-biased participants show significantly greater memory inaccuracy, and the difference between the two groups is statistically significant.

During the second visit, present-biased individuals are significantly more likely to exhibit directional misremembering aligned with motivational factors compared to time-consistent peers, though this difference is not significant in terms of intensity. Future-biased participants, by contrast, show no significant difference from time-consistent individuals on either margin. Wald tests confirm that present- and future-biased participants differ significantly in their behavior during this period.

When using the intensity of bias as the explanatory variable, results are consistent: future-biased participants do not differ significantly from time-consistent individuals at the 5% level during either visit. Present-biased participants, however, show lower memory inaccuracy during the first visit but significantly higher likelihood and intensity of directional misremembering aligned with motivational factors during the second. Again, differences between present and future bias are statistically significant across all specifications.

These results indicate that present- and future-biased individuals exhibit distinct patterns of misremembering. The elevated levels of motivated misremembering among present-biased individuals cannot be attributed to a general link between time inconsistency and poor memory.

Turning to directional misremembering not aligned with motivational factors, patterns diverge again. Using the dummy specifications, future-biased participants exhibit more of this behavior in the second visit — potentially reflecting a different form of motivated distortion — while no difference appears in the first visit. Present-biased participants

[17] If we add the coefficients of the *Present bias dummy* and *P. bias* × *Second visit* in specification (3) of Table C.9, the Wald test indicates that the sum is significantly different from zero (p-value = 0.0025). Hence, even though the *Present bias dummy* is not significantly different from zero, the significant interaction term indicates that it is significant during the second visit, making it significant overall, as seen in specification (1). Similarly, the sum of the coefficients of *Present bias degree* and *P. bias degree* × *Second visit* is significantly different from zero (Wald test, p-value = 0.0001). Therefore, the significance of *Present bias degree*, as seen in specification (1), stems from the second visit.

[18] In specification (3) of Table C.10, the Wald test shows that the sum of the coefficients for the *Present bias dummy* and *P. bias* × *Second visit* is not significantly different from zero (p-value = 0.260). In contrast, the sum of the coefficients for *Present bias degree* and *P. bias degree* × *Second visit* is significantly different from zero (Wald test, p-value < 0.001). This indicates that the significance of *Present bias degree*, observed in specification (1), arises from the second visit.

Table 4
Robustness Analysis of the Relationship Between Present Bias, Future Bias, and Misremembering.

Directional Misremembering Aligned with Motivational Factors

	First Visit		Second Visit		First Visit		Second Visit	
	Dummy	Intensity	Dummy	Intensity	Dummy	Intensity	Dummy	Intensity
Present Bias Dummy	−0.158*	−0.158*	0.392***	0.491				
	(0.088)	(0.088)	(0.122)	(0.501)				
Future Bias Dummy	0.556***	0.985**	0.048	−0.345				
	(0.199)	(0.402)	(0.164)	(0.480)				
Present Bias Intensity					−0.059**	−0.082**	0.096***	0.412***
					(0.026)	(0.037)	(0.019)	(0.122)
Future Bias Intensity					0.171*	0.232*	−0.016	−0.035
					(0.097)	(0.137)	(0.038)	(0.085)
Constant	0.158*	0.158*	0.286***	0.929**	0.195**	0.271**	0.345***	0.559**
	(0.088)	(0.088)	(0.087)	(0.389)	(0.085)	(0.120)	(0.070)	(0.280)
Observations	33	33	71	71	33	33	71	71
R^2	0.347	0.388	0.142	0.032	0.249	0.182	0.172	0.242
H0: PB=FB	<0.001	0.007	0.039	0.052	0.017	0.030	0.006	<0.001

Directional Misremembering Not Aligned with Motivational Factors

	First Visit		Second Visit		First Visit		Second Visit	
	Dummy	Intensity	Dummy	Intensity	Dummy	Intensity	Dummy	Intensity
Present Bias Dummy	0.588***	0.941**	−0.091	−0.136				
	(0.125)	(0.353)	(0.063)	(0.101)				
Future Bias Dummy	0.333	0.667	0.409***	0.489**				
	(0.284)	(0.569)	(0.144)	(0.225)				
Present Bias Intensity					0.099**	0.408	−0.091***	−0.122**
					(0.046)	(0.248)	(0.032)	(0.048)
Future Bias Intensity					0.059	0.232	0.032	0.029
					(0.105)	(0.224)	(0.052)	(0.060)
Constant	< 0.001	< 0.001	0.091	0.136	0.182**	−0.005	0.224***	0.301***
			(0.063)	(0.101)	(0.072)	(0.174)	(0.066)	(0.102)
Observations	36	36	48	48	36	36	48	48
R^2	0.374	0.172	0.265	0.180	0.106	0.314	0.061	0.042
H0: PB=FB	0.417	0.684	<0.001	0.003	0.724	0.558	0.026	0.028

All Misremembering

	First Visit		Second Visit		First Visit		Second Visit	
	Dummy	Intensity	Dummy	Intensity	Dummy	Intensity	Dummy	Intensity
Present Bias Dummy	0.430***	0.783**	0.344***	0.453				
	(0.151)	(0.360)	(0.123)	(0.481)				
Future Bias Dummy	0.592***	1.092***	0.267*	−0.117				
	(0.181)	(0.365)	(0.142)	(0.419)				
Present Bias Intensity					0.057	0.337	0.077***	0.387***
					(0.051)	(0.249)	(0.018)	(0.121)
Future Bias Intensity					0.145*	0.306**	0.011	−0.013
					(0.084)	(0.150)	(0.053)	(0.097)
Constant	0.158*	0.158*	0.333***	0.967***	0.317***	0.220	0.438***	0.673***
	(0.087)	(0.087)	(0.088)	(0.364)	(0.090)	(0.177)	(0.070)	(0.252)
Observations	44	44	81	81	44	44	81	81
R^2	0.246	0.172	0.096	0.022	0.092	0.217	0.092	0.218
H0: PB=FB	0.426	0.539	0.584	0.135	0.323	0.898	0.209	0.001

display the opposite pattern: more in the first visit and less in the second.

Using bias intensity instead of dummies yields similar conclusions. Future-biased individuals do not differ significantly from time-consistent ones, while present bias intensity is associated with greater directional misremembering not aligned with motivational factors in the first visit but less in the second. Wald tests often indicate significant differences between present and future bias, underscoring that the direction of time bias matters for how individuals recall past choices.

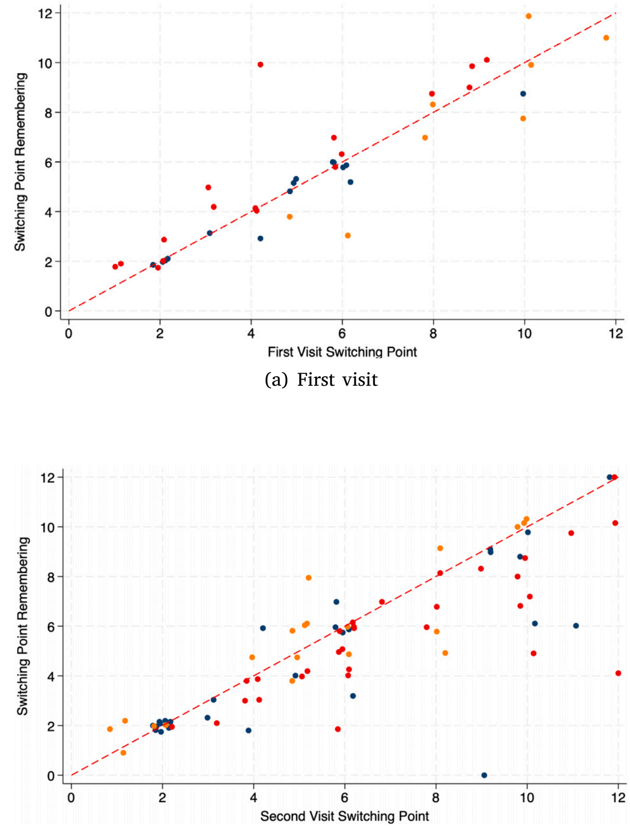
Finally, the bottom panel on overall misremembering shows that both types of time-inconsistent individuals misremember more than time-consistent ones during the first visit (based on dummies), while only present-biased participants continue to do so in the second visit. When using intensity measures, present-biased individuals misremember more in the second visit, while future-biased individuals do so in the first. Differences between the two groups are generally not significant in the aggregate, except in the final specification. Overall, misremembering patterns differ by bias type and context, particularly when the possibility of self-serving memory distortions is present.

Building on Table 4, Fig. 4 visualizes recall accuracy by plotting remembered against actual switching points during the visits. Being closer to the diagonal indicates more accurate memory. Observations are distinguished by time consistency (based on the difference in switching points across the two visits): blue dots represent time-consistent participants, while red (orange) dots denote present- (future-) biased peers. Instances of directional misremembering potentially due to motivational factors are illustrated by dots below the diagonal (remembering having switched to larger–later amounts earlier, as a sign of more virtuous behavior than in reality), while misremembering not in line with such motivational factors is represented by dots above the diagonal. As a consequence, Fig. 4 is tightly related to Table 4: the upper panel in Table 4 represents the points below the diagonal, the middle panel is connected to the points above the diagonal, and the bottom panel represents all the points. The present-bias dummy in the upper panel of Table 4 for the first visit indicates that present-biased participants (red dots) are somewhat closer to the diagonal – reflecting more accurate memory – when considering the points below the diagonal. The negative coefficient for present bias during the second visit expresses the idea that the red dots are, on average, farther away when considering directional misremembering in line with motivational factors, i.e., the area below the diagonal. Focusing on future-biased participants, the significant positive coefficient for the first visit indicates that they were, on average, farther from the diagonal than their time-consistent peers, while the non-significant coefficient indicates that during the second visit future-biased individuals did not engage in directional misremembering in line with motivational factors, illustrated by the points being, on average, not farther from the diagonal when considering only the area below the diagonal. Similar interpretations hold for the middle panel (focusing on the area above the diagonal) and for the bottom panel (which considers all points).

Fig. 4 also speaks to the cognitive uncertainty mechanism proposed by Enke and Graeber (2023): when uncertain about their true preferences, individuals may revert to a cognitive default, which here would be switching points nearer the center. Consider two participants: one present-biased and one time-consistent. If the former is more affected by cognitive noise (as suggested by Enke et al. 2025), they will tend to report a switching point closer to the center, while the latter will be less prone to do so. Because present-biased participants typically have higher switching points on average, this pull toward the center would generate a higher probability of what we classify as motivated misremembering. In this case, the appearance of motivation is observationally equivalent to greater cognitive noise, a non-motivational factor. Under such regression to the center, we would expect present-biased participants' dots to lie above the diagonal at low actual switching points and below it at high switching points. We do not observe this pattern in either visit: in the first visit, red dots tend to be below the diagonal; in the second, they are more often above it, regardless of the actual switching point. We also do not observe a similar 'pull to the center' pattern among future-biased participants. Taken together, cognitive noise alone cannot account for the directional and visit-specific patterns we observe.

In addition to cognitive noise, unstable preferences – where intertemporal choices fluctuate randomly over time (Drichoutis & Vassilopoulos, 2021; Hardardottir, 2017; Meier & Sprenger, 2015) – could mimic present bias if instability leads to inconsistent switching points across visits. This would produce equivalent patterns if instability correlates with lower memory accuracy overall, as unstable individuals might misremember due to weaker encoding of fluctuating choices. However, this would not generate the directional and visit-specific patterns we observe: instability should lead to non-directional errors in both visits, without the motivational alignment (e.g., recalling more virtuous choices) or the distinction between present- and future-biased groups in Table 4. Our data reveal directional errors primarily in the second visit for present-biased participants, and the opposite for future-biased participants, which is inconsistent with pure instability.

Third, encoding asymmetries due to salience or attention (Bordalo, Gennaioli, & Shleifer, 2022) might arise if immediate rewards in the second visit draw more attention, leading to stronger (or weaker) memory encoding for impulsive choices. This could generate equivalent patterns if present-biased individuals encode their impulsive decisions less vividly to avoid self-image threats, resulting in directional recall errors. However, it would diverge from our results if salience affects all participants similarly, yet we observe no such errors among time-consistent individuals. Moreover, encoding asymmetries would predict lower accuracy in the second visit across all groups, not the specific reversal for future-biased participants seen in Table 4.



(a) First visit

(b) Second visit

Fig. 4. Actual vs. recalled switching points. Red: present-biased; blue: time-consistent; orange: future-biased.

Finally, general memory deficits (unrelated to motivation) among present-biased individuals could explain lower accuracy, but this mechanism would not produce equivalent patterns: it should yield non-directional errors in both visits, without the motivational alignment or the placebo-like first-visit accuracy we observe. The distinct patterns for future-biased participants are difficult to reconcile with this explanation, as time inconsistency alone does not appear to drive the results (see Table 4).

While the alternative explanations above fit the data poorly, our design cannot cleanly separate them. A natural idea is to use inconsistency across visits (e.g., how much a person's switching point changes) as a proxy for cognitive noise. The problem is that present or future bias also creates exactly this kind of change. Put simply: if someone is present-biased, we expect their switching point to shift across visits even when they are perfectly consistent with their (biased) preferences. That same shift is what we would label as "noise" under an inconsistency proxy. As a result, any inconsistency-based measure mixes two things — random noise and systematic bias — and cannot tell them apart. To disentangle these mechanisms, future work would need an independent way to measure noise or preference stability (for example, a dedicated noise task or repeated blocks within a visit that change variability without changing the underlying preference), as in Enke, Graeber, & Oprea, 2025.

5. Conclusion

This study explores potential relationships between present bias and memory accuracy in intertemporal decision-making, examining patterns consistent with motivated misremembering. Using data from a classroom experiment with university students, we find evidence suggesting that individuals exhibiting present bias may show lower accuracy in recalling earlier choices, particularly when those choices involved immediate rewards. Present-biased participants appear to recall their past decisions as more future-oriented, a pattern consistent with, but not exclusive to, self-serving memory distortion, as non-motivational factors like cognitive noise could also contribute.

Our analysis suggests that present bias is significantly associated with the occurrence of directional misremembering (a potential manifestation of motivated misremembering) during the second visit, when immediate rewards were available. This relationship does not hold during the first visit, when no immediate rewards were involved, indicating that memory inaccuracies may be context-dependent, potentially reflecting ego-protective motives. Furthermore, a greater degree of present bias appears to be associated with a higher intensity of directional misremembering, potentially driven by motivation, though alternative mechanisms cannot be ruled out.

Importantly, our findings suggest that these patterns are not solely driven by time inconsistency. Future-biased individuals do not show similar patterns during the second visit, instead, exhibiting lower recall accuracy during the first visit, when their own bias may have been in conflict with the available choice structure. This asymmetry suggests that memory inaccuracy may not be a generic feature of time-inconsistent individuals, but could be influenced by the direction of the bias, potentially reflecting motivational factors, though non-motivational explanations like cognitive noise warrant further exploration.

Our findings indicate that present-biased individuals may exhibit patterns of directional misremembering, potentially contributing to lower awareness of their past impulsivity. This could, in some cases, hinder self-correction and align with the persistence of self-control problems, though other factors may also play a role. Theoretically, our results suggest that memory processes may be a relevant component to consider in models of intertemporal choice, warranting further investigation.

From a practical standpoint, interventions aimed at mitigating present bias might explore tools to enhance memory accuracy. Decision logs, reminders, or feedback mechanisms could potentially help individuals align their remembered and actual choices, which may support greater awareness of impulsive behavior, though their effectiveness requires testing.

Future research should further explore the interaction between time preferences and memory processes, especially in domains like health, education, or finance, where patterns of recall inaccuracies could potentially influence behavioral outcomes.

CRediT authorship contribution statement

Barna Bakó: Writing – review & editing, Project administration, Investigation, Funding acquisition, Conceptualization. **Antal Ertl:** Visualization, Software, Formal analysis, Data curation. **Hubert János Kiss:** Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used Chat-GPT in order to clarify the wording of the research text. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Declaration of competing interest

None.

Appendix A. Instructions

A.1. First visit to the classrooms

"Dear Participants,

Welcome to the research organized jointly by Corvinus University of Budapest and the Centre for Economic and Regional Studies. The project is led by Barna Bakó, Antal Ertl, and Hubert János Kiss, with the approval of the University's ethics committee.

Participation in the research is entirely VOLUNTARY. You can stop at any time without giving a reason. The task will take about 10 min. After the briefing, you will need to make simple decisions online. It is important to note that there is no objectively correct decision. Furthermore, we are not interested in the decisions of individuals but in how people generally decide in such situations.

During the task, you will make decisions about amounts of money to be paid out in two or four weeks, making a total of twelve decisions. For example, you can choose between receiving 10,000 HUF in two weeks or 12,800 HUF in four weeks. In two weeks, we will draw 10% of the participants, and the selected individuals will receive the amount corresponding to one of their decisions (at least 10,000 HUF) in the form of a Rewin shopping voucher (accepted at all known grocery stores). The payment will be made at the chosen time (two or four weeks later), and we will also come in for the class then.

Participation is completely ANONYMOUS. For identification, we ask for the first three characters of your Neptun code and the last four digits of your phone number, so we can assign the payments to the individuals. We do not request any personal data that could be used for identification during the research. Furthermore, all provided data is treated confidentially and is not disclosed to third parties. We will ask for details from the affected individuals for payment purposes, but this is only needed for accounting; it is not used for research.

Please remain quiet during decision-making time and do not disturb each other. Talking is not allowed! If you have a question, please indicate by raising your hand. Anyone who behaves inappropriately will be excluded and will also lose the chance to win money.

If you have any questions, feel free to ask now or contact the experiment leaders (Barna Bakó - barna.bako@uni-corvinus.hu, or Hubert János Kiss - hubertjanos.kiss@uni-corvinus.hu).

Thank you for your cooperation!"

Following this introduction, participants were presented with the 12 choices. After completing these choices, we asked them the following background questions:

"Your gender:
- Female
- Male
- Other/Prefer not to answer

Your mother's highest level of education:
- Elementary School
- Vocational School
- High School Diploma
- College
- University
- PhD

What grade did you receive in mathematics last semester?
- 1
- 2
- 3
- 4
- 5

Table B.5
Comparing the averages of participants' background variables in treatment 0 (First Visit) and 1 (Second Visit)
(PR) denotes test of proportion.
(RS) indicates the Wilcoxon rank-sum test.

Variable	First Visit (N=53)	Second Visit (N=93)	Test *p*-value
Female	45.28%	39.78%	(PR) 0.5172
Mother has diploma	81.13%	79.57%	(PR) 0.8200
Social rank	7.08	7.04	(RS) 0.9830
Math	4.00	3.98	(RS) 0.6178
Trust	2.81	2.76	(RS) 0.5552
Risk	3.17	3.19	(RS) 0.8523

Please place your family on a social ladder from 0 to 10, where 10 is the top, representing the best situation based on income, education, and job market status.

0 1 2 3 4 5 6 7 8 9 10

(a slider was provided to indicate the number)

In general, would you say most people can be trusted or that you cannot be too careful in dealing with people? Please answer on a scale from 1 to 5, where 1 means "you can't be too careful" and 5 means "most people can be trusted".

1
2
3
4
5

Please answer on a scale from 1 to 5, how willing are you to take risks? 1 means "not willing to take risks at all", and 5 means "very willing to take risks".

1
2
3
4
5

Again, please indicate your answer on a scale from 1 to 5. 1 means "not willing at all", and 5 means "very willing". How willing are you to give up something that is currently advantageous for you to benefit more from it in the future?

1
2
3
4
5

Please specify how many days you would be willing to wait MAXIMUM to receive 15,000 forints instead of 10,000! (Please provide a whole number)"

A.2. Second visit to the classrooms

Here, we provide the full English translation of the instructions given during our second visit to the classrooms.

"Dear Participants,

As we promised two weeks ago, we are back to continue the research. Two weeks ago, you made 12 decisions, choosing between receiving 10,000 HUF in two weeks or a higher amount in four weeks. We promised that 10% of the participants would receive their prize, at least 10,000 HUF in Rewin voucher form. We are going to conduct the draw now. Before the draw, however, you will have the opportunity to reconsider your decisions.

You will need to make decisions similar to those you made two weeks ago, but since two weeks have passed, the previous 10,000 HUF payment now represents an immediate 10,000 HUF, while the larger amount will be received in two weeks. Once you are done, we will draw the winners (10% of those present, rounded up) who will indeed receive the voucher amount corresponding to their decision.

For the draw, we will use the number in the upper right corner of the sheet, so please keep the sheet in front of you. We will also draw which decision will be the basis for the payment. For those who chose the immediate amount, we will pay on the spot, while for the other drawn participants, we will place the vouchers in an envelope, seal it, and they will receive the amount here in class in two weeks.

Please use the QR code below to access the online platform to make your decisions.

Thank you for your participation and cooperation!"

The participants faced the same choices as two weeks before, but now they could receive the earlier amount immediately, while the later amount would be received in two weeks.

A.3. Third visit to the classrooms

Here, we offer the English translation of the instructions given during our third visit to the classrooms. Note that participants were randomized into two groups and asked to remember their choices during our first/second visit.

"Dear Participants,

We hope you remember us from the beginning of the course when we visited you twice. During those sessions, you had to make 12 decisions regarding payments due at different times.

Now, we would like to assess how accurately you remember those previous decisions. Your task now is to make the same decisions you made during the FIRST/SECOND visit.

As before, we will draw 10% of the participants, and among those drawn, those whose current answers match their previous decisions in at least ten cases will receive a 5000 HUF Rewin voucher. The draw will be based on the number in the upper right corner of the sheet.

Eligible voucher recipients can collect their prizes from next Tuesday at the Department of Economics secretary's office (E.221.2) by stating the identifier used during the experiment (first 3 characters of Neptun code + last four digits of phone number).

We emphasize that we are not interested in what decision you would make now, but in how well you remember your previous decisions.

Thank you for your participation and cooperation!

Choice 1: On the SECOND OCCASION, we offered you two amounts with immediate payment and another payable in two weeks. Please indicate which option you chose!

Now HUF 10,000 (1) In two weeks HUF 10,000 (2) " We asked participants to recall their decisions for all 12 choices using the above question.

Appendix B. Randomization

Table B.5 shows participants' background variables measured during the first visit across treatments. There is no significant statistical difference between participants in the different treatments for these characteristics.

Table C.6
Switching points during the first and second Visits. The upper diagonal indicates present biased, while the lower indicates future biased decisions.

		Switching point - Second Visit												
		1	2	3	4	5	6	7	8	9	10	11	12	Total
Switching point - First Visit	1	0.0%	2.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%	0.0%	3.2%
	2	1.6%	14.4%	0.8%	3.2%	0.0%	4.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.8%	25.6%
	3	0.8%	0.0%	2.4%	1.6%	1.6%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.0%
	4	0.0%	0.0%	0.0%	2.4%	0.8%	1.6%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	5.6%
	5	0.8%	0.8%	0.0%	0.8%	3.2%	3.2%	0.0%	0.0%	0.0%	2.4%	0.0%	0.0%	11.2%
	6	0.0%	0.0%	0.0%	0.0%	4.0%	8.8%	1.6%	0.8%	1.6%	0.8%	0.0%	0.0%	17.6%
	7	0.0%	0.0%	0.0%	0.0%	1.6%	0.0%	0.0%	0.8%	0.0%	0.0%	0.8%	0.0%	3.2%
	8	0.0%	0.0%	0.0%	0.0%	0.0%	1.6%	0.8%	0.0%	0.0%	0.0%	0.8%	0.8%	4.0%
	9	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	1.6%	2.4%	2.4%	0.8%	0.8%	8.8%
	10	0.0%	0.8%	0.0%	0.0%	0.0%	0.8%	0.8%	1.6%	0.0%	4.0%	0.0%	0.0%	8.0%
	11	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.8%	0.0%	1.6%
	12	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%	0.0%	0.8%	3.2%
Total		3.2%	18.4%	3.2%	8.0%	11.2%	22.4%	3.2%	5.6%	4.0%	14.4%	3.2%	3.2%	100.0%

Table C.7
Average correct memories of earlier choices without omitting observations without switches.

		Present-biased	Time-consistent	Not present-biased	Future-biased	Rank-sum test		
		(1)	(2)	(3)	(4)	(1) vs (2)	(1) vs (3)	(1) vs (4)
Average of correctly remembered choices during	First visit	10.44	11.72	11.2	10.31			
	95% CI	(8.97 11.91)	(11.42 12.04)	(10.73 11.67)	(9.25 11.37)	0.006	0.212	0.284
	N	18	22	35	13			
	Second visit	10.67	11.27	11.02	10.70			
	95% CI	(10.05 11.28)	(10.79 11.76)	(10.53 11.50)	(9.77 11.63)	0.022	0.087	0.560
	N	33	33	60	27			

Table C.8
Pairwise Correlation Matrix.

	Misremembering	Misrem. Intensity	Switch Pt. 1	Switch Pt. 2	FB Dummy	Present Bias	Female	Math	Social Rank	Trust	Risk
Misremembering	1.000										
Misrem. Intensity	0.635*	1.000									
Switch Pt. 1	0.111	0.080	1.000								
Switch Pt. 2	0.238*	0.367*	0.703*	1.000							
FB Dummy	0.158	0.004	0.409*	−0.056	1.000						
Present Bias	0.237*	0.156	−0.255*	0.304*	−0.424*	1.000					
Female	0.202*	0.156	−0.078	−0.129	0.131	0.001	1.000				
Math	0.046	−0.251*	0.022	−0.029	0.038	0.007	−0.041	1.000			
Social Rank	−0.106	−0.020	0.135	−0.006	0.035	−0.104	−0.167	0.017	1.000		
Trust	0.008	0.092	−0.012	0.047	−0.020	0.099	−0.090	−0.040	0.028	1.000	
Risk	0.073	0.048	0.052	0.022	−0.028	−0.080	−0.074	−0.221*	−0.020	−0.073	1.000

Note: * indicates significance at the 5% level.

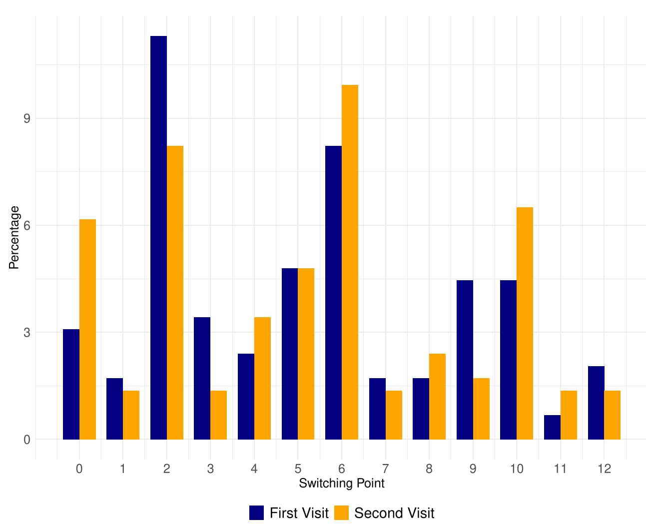


Fig. C.5. Distribution of switching points for the first and second visits.

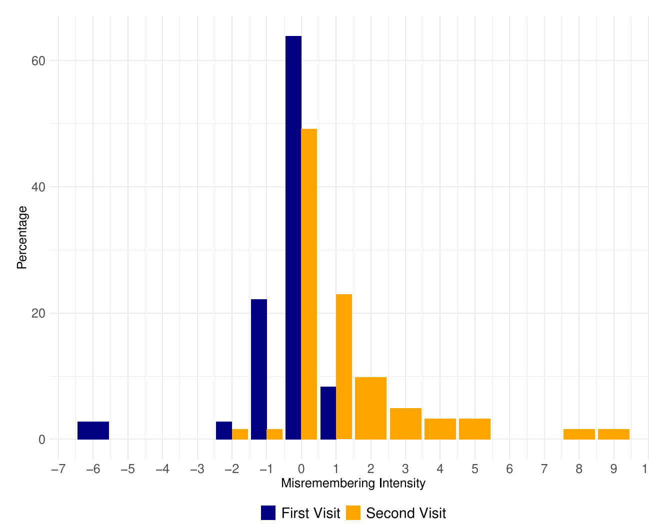


Fig. C.6. Histogram of the intensities of misremembering during the first and second visits.

Table C.9
OLS regression. Dependent variable: dummy for instance of misremembering.

VARIABLES	Dummy of Misremembering					
	(1)	(2)	(3)	(4)	(5)	(6)
Second visit	0.312**	0.128	0.128	0.314**	0.186	0.185
	(0.096)	(0.122)	(0.121)	(0.096)	(0.111)	(0.109)
Present bias dummy	0.250*	−0.158	−0.130			
	(0.099)	(0.086)	(0.135)			
P. bias x Second visit		0.550**	0.523**			
		(0.150)	(0.195)			
Present bias degree				0.077**	−0.046	−0.043
				(0.017)	(0.025)	(0.039)
P. bias degree x Second visit					0.144**	0.141**
					(0.032)	(0.048)
Female			0.115			0.130
			(0.112)			(0.108)
Mother has diploma			0.056			0.048
			(0.145)			(0.146)
Social rank			−0.017			−0.006
			(0.032)			(0.032)
Math			0.023			0.043
			(0.052)			(0.053)
Trust			0.073			0.048
			(0.052)			(0.056)
Risk attitude			0.053			0.041
			(0.060)			(0.059)
Constant	0.048	0.158	−0.276	0.056	0.150	−0.334
	(0.079)	(0.086)	(0.390)	(0.073)	(0.082)	(0.384)
Observations	85	85	85	85	85	85
R^2	0.190	0.247	0.282	0.228	0.272	0.302

Robust standard errors in parentheses.
*** p<0.001, ** p<0.01,* p<0.05

Appendix C. Additional figures and tables

C.1. Switching points distributions

Fig. C.5 displays the distribution of switching points.[19] Relative to the first visit, the distribution shifts to the right in the second visit, indicating that participants generally required higher compensation to wait an additional two weeks when the earlier payment date was immediate. While the overall average switching point remained stable across visits (approximately 5.1), restricting the analysis to participants who switched reveals an increase from 5.54 in the first visit to 5.92 in the second. This shift suggests that the immediacy of the earlier payment influenced decision-making, consistent with the presence of present bias.

C.2. Transition table of switching points

Table C.6 presents a transition table of switching points across the two visits. The diagonal elements are relatively high, indicating that many participants maintained the same switching point between visits. At the same time, there is notable mass above the diagonal, suggesting that several participants increased their switching point in the second visit. This rightward shift implies that participants generally required higher compensation to delay payment when the earlier option was immediate, consistent with the presence of present-biased preferences.

Additionally, we examine the impact of including observations with no switching point in the analysis. Table C.7 replicates the comparisons presented in Table 2 of the main text, this time including individuals who did not switch. The only change in our findings is that the difference in memory accuracy between present-biased and non-present-biased participants during the second visit is no longer statistically significant at the 5% level.

C.3. Descriptives of motivated misremembering

Considering the dummy for motivated misremembering, when participants were asked to remember choices during the first visit, the rate of misremembering is 22.22%, while for the second visit, the rate climbs to 46.38%. The difference is significant at the 5% level according to the test of proportions (p-value = 0.027). Regarding the intensities of misremembering, the averages are 0.31 and 0.99 during the first and second visits, respectively. Fig. C.6 indicates that the distribution is more skewed to the right in the case of the second visit, with relatively more non-negative intensities that are also larger in size. The Wilcoxon rank-sum test detects a significant difference in intensities (p-value = 0.0078). All this strongly indicates that instances of misremembering are significantly more pronounced during the second visit when the lure of immediate reward is present.

C.4. Correlation matrix of variables

See Table C.8.

C.5. Regression analysis — dependent variable: motivated misremembering dummy

See Table C.9.

[19] For further details, Table C.6 in Appendix C presents a transition table of switching points.

Table C.10
OLS regression. Dependent variable: Misremembering intensity.

	Intensity of Misremembering					
	(1)	(2)	(3)	(4)	(5)	(6)
Second visit	0.988**	0.771	0.610	0.789**	0.377	0.232
	(0.289)	(0.400)	(0.428)	(0.276)	(0.319)	(0.350)
Present bias dummy	0.323	−0.158	−0.077			
	(0.373)	(0.086)	(0.341)			
P. bias x Second visit		0.649	0.655			
		(0.510)	(0.695)			
Present bias degree				0.349**	−0.046	−0.064
				(0.121)	(0.025)	(0.098)
P. bias degree x Second visit					0.464**	0.490**
					(0.128)	(0.178)
Female			0.206			0.186
			(0.354)			(0.321)
Mother has diploma			0.165			0.112
			(0.555)			(0.386)
Social rank			0.047			0.159
			(0.097)			(0.096)
Math			−0.362			−0.282
			(0.243)			(0.253)
Trust			0.243			0.223
			(0.244)			(0.161)
Risk attitude			0.122			0.083
			(0.211)			(0.170)
Constant	0.028	0.158	0.096	−0.153	0.150*	−0.770
	(0.126)	(0.086)	(1.376)	(0.149)	(0.082)	(1.271)
Observations	85	85	85	85	85	85
R^2	0.098	0.105	0.183	0.267	0.307	0.370

Robust standard errors in parentheses.
*** p<0.001, ** p<0.01,* p<0.05

C.6. Regression analysis — dependent variable: motivated misremembering intensity

See Table C.10.

Data availability

We provided a github repository link in the paper to access the data as well as the codes used for the analysis.

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