Remembering Past Present Biases

Barna Bakó[a], Antal Ertl[a], Hubert János Kiss[1b,a]

[a]*Department of Economics, Corvinus University of Budapest, Fővám tér 8, Budapest, 1093, Hungary*
[b]*KRTK KTI, Tóth Kálmán utca 4, Budapest, 1097, Hungary*

Abstract

This study investigates how present bias affects memory accuracy regarding earlier decisions in intertemporal decision-making. In a classroom experiment with university students, participants made choices between smaller, immediate rewards and larger, delayed rewards over two visits, followed by a third visit where they were asked to recall their prior decisions. Descriptive statistics reveal that participants with present bias exhibit lower memory accuracy compared to time-consistent peers, particularly in scenarios involving immediate rewards. Regression analysis confirms that motivated misremembering—recalling past decisions as more virtuous than they actually were—explains the reduced memory accuracy.

Keywords: Experiment, Memory, Motivated misremember, Present bias, Time preference
JEL: C90, D01, D9

1. Introduction

Present bias, the phenomenon of exhibiting a lower immediate and higher later discount factor, is closely related to procrastination—the tendency to

[1]The project identified as EKOP-CORVINUS-24-3-015 was carried out with the support of the National Research, Development, and Innovation Fund provided by the Ministry of Culture and Innovation, as part of the University Research Scholarship Program for the 2024/2025 academic year. Barna Bakó gratefully acknowledges financial support from the Hungarian National Research, Development and Innovation Office (FK-132343). Hubert J. Kiss gratefully acknowledges financial support from the Hungarian Academy of Sciences, Momentum Grant No. LP2021-2. The data and codes used in this paper are available online at: `https://github.com/ToniErtl/Remembering_Past_Present_Biased`.

delay tasks that involve effort or costs, even when those efforts yield substantial future benefits. As a consequence, present bias is associated with negative outcomes in many domains, such as education (e.g., Kim and Seo, 2015), the labor market (e.g., Paserman, 2008), or health (e.g., Bradford et al., 2017). However, present bias is not inherently problematic if individuals are sophisticated (O'donoghue and Rabin, 1999; Cobb-Clark et al., 2024)—that is, aware of their bias and capable of mitigating it, for example, through the use of commitment devices. A key prerequisite for such awareness is the ability to recall instances where one acted impulsively, driven by the allure of immediate rewards.

While awareness is part of theoretical models (e.g., O'donoghue and Rabin, 2001), empirical knowledge about whether individuals are aware of their present bias remains limited. The existing evidence suggests that individuals may not be aware of their present bias (Wong, 2008; Augenblick and Rabin, 2019). We contribute to the literature by examining whether present-biased individuals struggle more to recall previous decisions, particularly those involving the temptation of an immediate reward, compared to their time-consistent peers. Such memory inaccuracy may be driven by a desire to maintain a positive self-image. For example, Carlson et al. (2020) show that individuals tend to recall themselves as being more generous than they actually were.

In our incentivized classroom experiment, university students made 12 choices between a smaller, sooner monetary reward and a larger, later one across two time frames. The smaller, sooner amount was fixed, while the larger, later amount increased with each subsequent decision. In such elicitation tasks, participants typically choose the smaller, sooner reward in the initial decisions and switch to the larger, later reward in later choices.

During the first visit, participants chose between receiving different amounts of money in 2 and 4 weeks. Two weeks later, during the second visit, they repeated the exercise, choosing between immediate receipt or a delay of two weeks. Based on their choices, we categorized students according to their time consistency. Time-consistent participants switched to the larger, later reward at the same point in both visits. A participant is considered present-biased if they require greater compensation to delay receiving money during the second visit (with an immediate reward available) compared to the first visit—indicating a later switch to the larger, delayed payment. This approach allows us to measure both the existence and intensity of present bias.

For example, during the first visit, Alex switches at decision 2, Bobby

at decision 4, and Charlie at decision 6. In the second visit, their respective switches occur at decisions 2, 5, and 12. Alex is time-consistent, while Bobby and Charlie are present-biased, with Charlie exhibiting a greater degree of present bias.

A month after the second visit, we returned to the classrooms and asked students to recall their choices, incentivizing the accuracy of their memories. Students were randomized into two groups: one group was tasked with recalling their decisions from the first visit (made without the temptation of an immediate reward, serving as a baseline measure of forgetting), while the other group was asked to recall their decisions from the second visit (made under the temptation of immediate gratification).

Our primary objective is to investigate whether present-biased participants—who are more likely to act impulsively when an immediate reward is available—are also more likely to recall having acted in a more favorable (less impulsive) manner. This focus enables us to examine not only the existence of memory inaccuracies but also their direction. Following Carlson et al. (2020), we refer to such directional memory inaccuracy as motivated misremembering.

We assess both the existence and extent of motivated misremembering by calculating the difference between the remembered and actual switching points. For example, assume Alex, Bobby, and Charlie were tasked with recalling their decisions during the second visit. They remember switching to the larger, later reward at decision points 2, 4, and 7, respectively. Alex recalls their 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 in Charlie's recalled versus actual decision indicates that their motivated misremembering is more intense.

The literature on motivated memory (Amelio and 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. Hence, we hypothesize that present-biased students will recall their decisions during the second visit with less accuracy than their time-consistent counterparts. This discrepancy is expected to arise during the second visit, as the availability of an immediate reward is more likely to trigger impulsive decisions in present-biased participants, favoring the smaller, sooner rewards.

Returning to our earlier example, we hypothesize that if Alex, Bobby, and Charlie were selected to recall their decisions during the second visit, Alex would perform better than Bobby and Charlie. Furthermore, Charlie would perform worse in the recall exercise than Bobby.

Two studies are closely related to our work. Sial et al. (2023) examine the relationship between biased memories and self-control in the context of gym attendance. They find that individuals with more biased memories are more naive about their time inconsistency but not more time-inconsistent, suggesting no connection between present bias and memory bias. Conversely, Chew et al. (2020) report that individuals who recall their past performance in a cognitive task more favorably tend to exhibit greater present bias. Thus, the limited evidence on the relationship between present bias and memory accuracy remains ambiguous, indicating the need for further investigation. We contribute to this endeavor by focusing directly on intertemporal choice, which allows us to identify the presence of present bias and assess recall accuracy in an environment that explicitly contrasts smaller, sooner benefits with larger, later rewards. This approach enables us to investigate whether misremembering serves as a potential mechanism connecting present bias to its negative consequences, as failing to recall impulsive behavior may reduce attention to addressing the problems that arise from it.

Despite differences in experimental design, our findings align with those of Chew et al. (2020). Approximately one-third of the participants in our sample were present-biased and exhibited lower recall accuracy compared to their time-consistent peers. This inaccuracy was observed not only for choices made during the second visit, when the temptation of an immediate monetary reward was present, but also for decisions made during the first visit. Focusing on motivated misremembering—instances where participants recalled past decisions in a more favorable light—we find that present-biased participants were significantly more likely (at the 1% level) to exhibit such behavior during the second visit, when an immediate reward was available. However, present bias was not correlated with the intensity of motivated misremembering.

When considering the degree of present bias, we observe a significant positive association (at the 1% level) with both the likelihood of exhibiting motivated misremembering and its intensity during the second visit. Specifically, participants who are more present-biased—requiring greater compensation for a two-week delay during the second visit compared to the first—are more likely to exhibit motivated misremembering and display a larger extent of

it (i.e., a greater difference between recalled and actual choices). No significant correlations were observed during the first visit, where the lure of an immediate reward was absent.

The rest of the study is structured as follows. Section 2 describes the data collection process and the experimental design. Section 3 contains the findings. Section 4 concludes.

2. Experimental design and data collection

The participants were students at the Corvinus University of Budapest who attended the course *Macroeconomics*, a core course in the Business Administration and Management bachelor program, during the spring semester of the 2023/2024 academic year. A total of 388 students were enrolled in this course across 13 classrooms, forming the initial participant pool.

To measure present bias and memory, we visited the classrooms three times, as shown in Figure 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 took place during the second week of classes (February 19–23, 2024). We were allowed to enter at the beginning of each class. Instruction sheets were distributed to students who wished to participate, and the instructions were read aloud. Participation was explicitly stated to be voluntary, with students free to withdraw at any time. The instructions provided 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 the participants, selected randomly, would receive vouch-

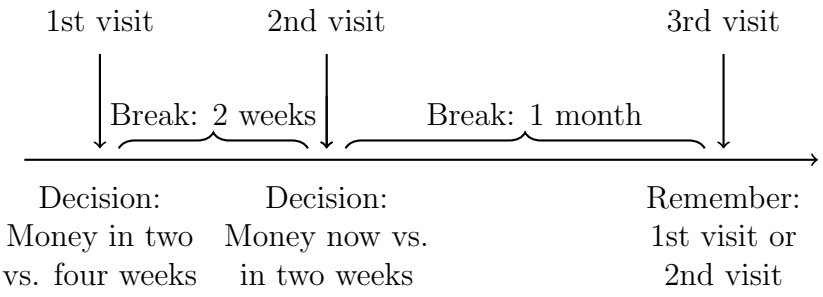

Figure 1: Timeline of the experiments

ers redeemable at various shops and major chains based on their choices. Anonymity of the experiment was also emphasized. At the end of the sheet, participants found a QR code and a URL linking them to an online platform where they could submit their responses using laptops or smartphones. 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.

[2]Appendix A.1 contains the instructions.

[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 and Kiss, 2020; Horn et al., 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.

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 in order. 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 et al., 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.[5]

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, we offered participants the

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

[5]For details, see Appendix A.1.

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).[6]

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 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 2.[7] Participants who, during the second visit—with the option of immediate payment—chose a later switching point than during the first visit are considered either present-biased (or, more neutrally, present-focused). These participants are represented to the right of the bar at zero in 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 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, indicating present bias.[8] 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

[6]Appendix A.2 provides the instructions given to participants during the second visit.

[7]Figure 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.

[8]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).

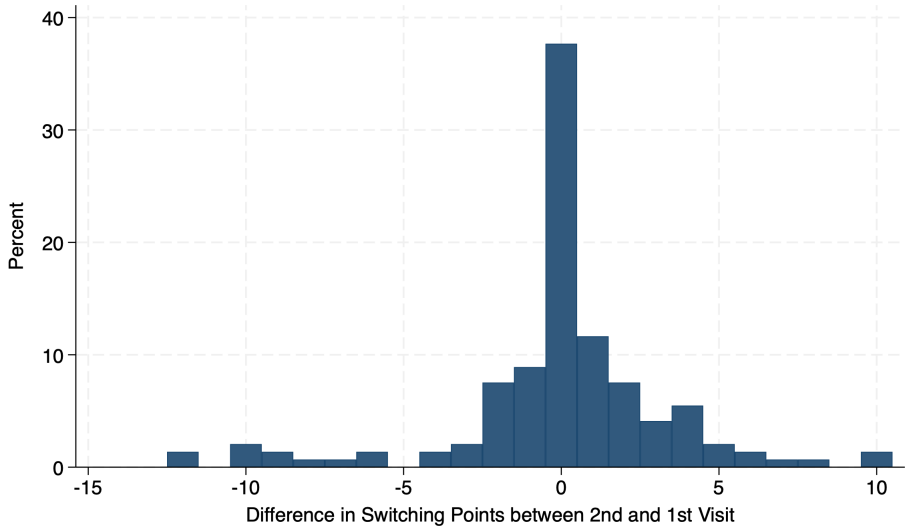

Figure 2: Distribution of the difference in switching points

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 pronounced present bias.

In our analysis, we consider both definitions of present bias: the binary definition and the one accounting for its intensity.[9] Our primary focus is on how well present-biased participants recall their choices from the first 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.[10]

As pre-registered, we excluded participants who made inconsistent choices by switching multiple times during either the first or second visit. There were

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

[10] 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.

9 such inconsistent participants during the first visit and 1 during the second visit.[11]

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).[12]

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 reveal causal relationships.[13] Appendix B confirms that the randomization was successful, as no statistically significant differences were found in participants' background characteristics that we assessed during the first visit.

2.4. Hypotheses

We pre-registered our study at `https://aspredicted.org/r44b-gbnb.pdf` to investigate whether participants exhibiting present bias recall their

[11] Choice inconsistency is weakly and negatively correlated with mathematical abilities, with a correlation coefficient of -0.1526 and a p-value of 0.0580.

[12] Appendix A.3 provides the instructions given to participants during the third visit.

[13] 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, identifying 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 understanding motivated memory.

choices from the second visit differently than their time-consistent counterparts. Specifically, we aim to determine whether they are more likely to adjust their memories to favor a positive self-image by recalling having chosen delayed rewards more frequently. We assess 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), indicating misremembering in a direction that reflects a more favorable self-image during the second visit. We hypothesize that present-biased participants are more likely to exhibit such motivated misremembering.

In the pre-registration, we also considered that not only the occurrence of motivated misremembering 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 $X - Y$. Based on the literature on motivated memory, we hypothesize that greater motivated misremembering intensity is more strongly associated with present bias.

	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

Table 1: Example of the variables of main interest

Table 1 uses the example of the Introduction illustrating how our main variables are calculated, with the remembered switch referring to the second visit. We pre-registered that present bias is associated with both the occurrence and intensity of motivated misremembering. Specifically, we hypothesized and pre-registered that being present-biased is positively correlated with both measures of motivated misremembering. That is, the Alexes among our participants are less likely to misremember (and exhibit a lower intensity of misremembering) than the Bobbys and Charlies in our sample. Additionally, in an exploratory manner, we conjecture that the degree of present bias is also positively associated with these measures. That is, the

Charlies in our sample are more likely to misremember (and exhibit a higher intensity of misremembering) 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 Section 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.

		Present-biased (1)	Time-consistent (2)	Not present-biased (3)	Rank sum test (1) vs (2)	Rank sum test (1) vs (3)
Average of correctly remembered choices during	First visit	11.06	11.84	11.52		
	95% CI	(10.32 11.80)	(11.66 12.02)	(11.20 11.84)	0.0064	0.1454
	N	17	19	27		
	Second visit	10.58	11.2	11.18		
	95% CI	(9.94 11.22)	(10.67 11.73)	(10.83 11.53)	0.027	0.0416
	N	31	30	50		

Note: Observations without switching points are excluded.

Table 2: Average correct memories of earlier choices.

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 would be more affected by motivated misremembering, potentially leading to fewer correctly remembered choices during the second visit. The descriptive statistics support this hypothesis: 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 time-consistent participants are used as the baseline group.

Interestingly, 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 suggests that the presence of an immediate reward is negatively associated with memory accuracy.

Figure 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 reveals a clear negative relationship: as the intensity of present bias increases, the accuracy of recalling earlier choices declines. 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.

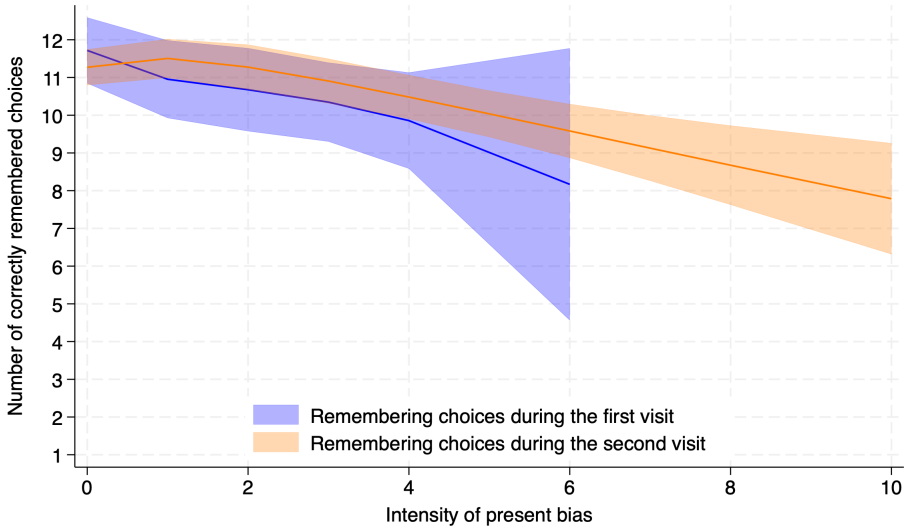

Figure 3: Fractional polynomial plot on the relationship between the average correct memories of earlier choices and the intensity of present bias with 95% confidence interval

Overall, whether considering a dummy variable or the intensity measure, participants exhibiting present bias perform worse in recalling earlier decisions made during both the first and second visits.

3. Findings

The descriptive statistics suggest an association between present bias and the accuracy of recalling earlier choices, aligning with our pre-registered hypothesis. Specifically, the hypothesis posits that participants are more likely

to recall choosing delayed rewards more frequently than they actually did. Accordingly, our objective is to determine whether present-biased participants are more prone to recall switching to later, larger rewards earlier than they actually did—instances we term motivated misremembering—compared to their peers.

To enable a clear comparison, we exclude future-biased participants and designate time-consistent participants as the baseline group. Furthermore, we narrow 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 exhibited motivated misremembering, while for the second visit, this proportion increased to 49.2

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 introduce a motivated misremembering dummy variable, 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 wait than they truly did, suggesting they recall being more future-oriented than they actually were. 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, as we lack a compelling theoretical rationale or supporting literature to explain such instances of misremembering.

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 = -0.1991, p-value = 0.3295). However, a significant association emerges during the second visit (correlation coefficient = 0.4915, p-value 0.0001)[14].

These findings strongly suggest that present bias influences the accuracy of recalling earlier choices only when those choices involve immediate rewards. This indicates that participants may adjust their memories to maintain a positive self-image in situations where resisting the temptation of immediate gratification was particularly challenging.

To confirm the findings, we present a regression analysis.[15] Although our hypotheses referred to remembering decisions during the second visit, for sake of completeness Table 3 contains the recall of decisions made during both visits. The table presents the results of OLS regressions, with the dependent variables being the motivated misremembering *dummy* (columns (1) and (3)) and the motivated misremembering *intensity* (columns (2) and (4)). The primary explanatory variable in all cases is the present bias dummy.

Recall of decisions:	First Visit		Second Visit	
Misremembering	Dummy	Intensity	Dummy	Intensity
Present bias dummy	-0.158	-0.158	0.392**	0.491
	(0.0871)	(0.0871)	(0.122)	(0.499)
Constant	0.158	0.158	0.286**	0.929*
	(0.0871)	(0.0871)	(0.0869)	(0.388)
Observations	26	26	59	59
R^2	0.048	0.048	0.153	0.017

Robust standard errors in parentheses

** p<0.01, * p<0.05

Table 3: Relationship between being present-biased and motivated misremembering

[14]These values correspond for our database being restricted according to our pre-registration. For the full sample, Fisher's exact test p-values change to 0.125 and 0.043, respectively. For the pairwise correlations, the correlation coefficient is -0.6038 for the first, and 0.5034, both statistically significant at the 1%

[15]The relationship could be influenced by various confounding factors, such as cognitive and non-cognitive abilities or family background. To address these potential confounders, we collected information on several relevant variables during the questionnaire administered in the first visit. We conduct the same regression analysis with those control variables and report the findings in sections Appendix C.4 and Appendix C.5.

We find no significant association between present bias and the presence or intensity of motivated misremembering during the first visit. However, consistent with our hypothesis, a significant positive relationship emerges during the second visit: present-biased participants are nearly 40% more likely to engage in motivated misremembering compared to their time-consistent peers. When considering the intensity of motivated misremembering as the dependent variable, the coefficient remains positive but falls short of statistical significance.

Table C.7 in Appendix C.4 presents regression results using a dummy variable for motivated misremembering while controlling for participants' observable characteristics (gender, mother's education, 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 indicates a higher likelihood of motivated misremembering at that time. The present bias dummy is also significant, showing that present-biased participants are more prone to motivated misremembering. Furthermore, an interaction term reveals that the influence of present bias is specific to the second visit. These findings hold also when using the degree of present bias as the main explanatory variable.[16] Interestingly, none of the control variables are statistically significant.

Table 4 presents regression results similar to those in Table 3, but here the dependent variable is the degree of present bias. Consistent with the findings in Table 3, no significant association is observed between the degree of present bias and motivated 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, aligning with our hypothesis. Specifically, a one-unit increase in present bias corresponds to a nearly 10% higher likelihood of motivated misremembering. Additionally, a higher degree of present bias is associated with increased intensity of

[16] If we add the coefficients of the *Present bias dummy* and *P. bias* × *Second visit* in specification (3) of Table C.7, 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.

Recall of decisions:	First Visit		Second Visit	
Misremembering	Dummy	Intensity	Dummy	Intensity
Intensity of Present Bias	-0.0456	-0.0456	0.0981**	0.418**
	(0.0255)	(0.0255)	(0.0198)	(0.125)
Constant	0.150	0.150	0.337**	0.527
	(0.0831)	(0.0831)	(0.0747)	(0.306)
Observations	26	26	59	59
R^2	0.040	0.040	0.188	0.242

Robust standard errors in parentheses

** p<0.01, * p<0.05

Table 4: Relationship between the degree of present bias and motivated misremembering

motivated misremembering.

Table C.8 in Appendix C.5 provides regression results where the dependent variable is the intensity of motivated misremembering, including additional control variables. The results show that misremembering intensity is higher during the second visit. While the present bias dummy is not significant in these regressions across all specifications, the degree of present bias as the main explanatory variable yields a significant positive coefficient. This indicates that participants with greater present bias exhibit more intense misremembering, with the effect primarily driven by the second visit.[17] As before, none of the control variables are statistically significant.

4. Conclusion

This study investigates the relationship between present bias and memory accuracy in intertemporal decision-making, focusing on the phenomenon of motivated misremembering. Using data from a classroom experiment with

[17] In specification (3) of Table C.8, 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 = 0.26). 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 = 0.0003). This indicates that the significance of *Present bias degree*, observed in specification (1), arises from the second visit.

university students, we find compelling evidence that individuals exhibiting present bias are more prone to recalling their earlier choices inaccurately, particularly when those choices involved immediate rewards. Notably, present-biased participants often reconstruct their past decisions to appear more future-oriented, consistent with the concept of motivated misremembering.

Our analysis reveals that present bias is significantly associated with the occurrence of motivated misremembering during the second visit, when the temptation of immediate gratification was present. Specifically, present-biased individuals are approximately 40% more likely to engage in motivated misremembering than their time-consistent peers. Furthermore, a greater degree of present bias correlates with a higher intensity of misremembering. However, no such associations are observed during the first visit, where immediate rewards were absent.

These findings highlight the role of memory distortions in exacerbating the psychological and behavioral challenges associated with present bias. By misremembering impulsive choices as more virtuous, individuals may reduce their awareness of their biases, hindering their ability to adopt effective strategies for self-control. This underscores the need to account for memory as a mediating factor in theoretical models of intertemporal choice.

From a practical standpoint, our results suggest that interventions aimed at mitigating present bias could benefit from incorporating components that enhance memory accuracy. For instance, tools such as decision logs or external feedback mechanisms might help individuals align their remembered and actual choices, promoting more informed and consistent decision-making.

Future research could build on these insights by exploring the interplay between memory accuracy, present bias, and individual differences to determine whether heterogeneity exists in the findings. Additionally, investigating similar memory distortions in other domains, such as health or financial behaviors, could provide a deeper understanding of the broader implications of motivated memory biases.

Appendix A. Instructions

Appendix 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 minutes. 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

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 can't 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)"

Appendix 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.

Appendix 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.

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

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.

Appendix C. Additional Figures and Tables

Appendix C.1. Switching Points distributions

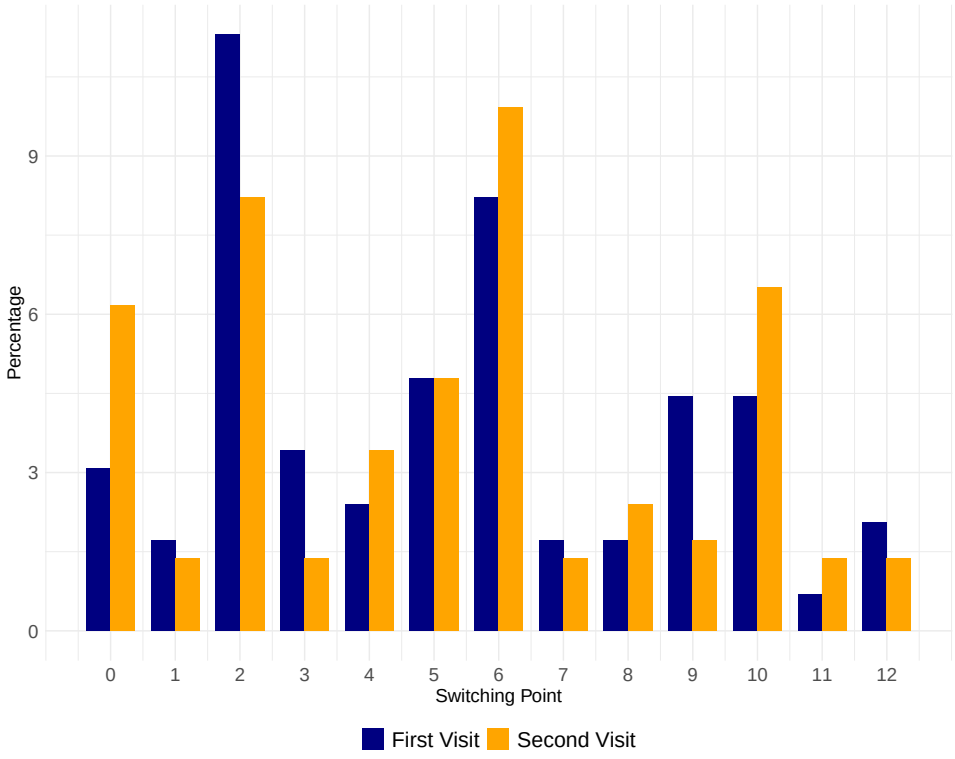

Figure C.4: Distribution of Switching Points for the 1st and 2nd Visits

Figure C.4 shows the distribution of switching points.[18] Compared to the first visit, the distribution shifted to the right during the second visit, indicating that participants generally demanded higher compensation to wait an additional two weeks when the earlier payment date was immediate. The average switching point remained the same during the two visits (around 5.1); excluding those who did not switch, average switching points increased from 5.54 during the first visit to 5.92 during the second visit. This shift suggests that the temptation of receiving money immediately may be influencing their decisions, pointing to the presence of present bias.

[18]Table C.6 in Appendix C presents a transition table of switching points for further details.

Appendix C.2. Transition Table of Switching Points

Switching point - First Visit	Switching point - Second Visit: 1	2	3	4	5	6	7	8	9	10	11	12	Total
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.6: Switching points during the First and Second Visits. The upper diagonal indicates present biased, while the lower indicates future biased decisions.

Appendix 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 = 0.0273). Regarding the intensities of misremembering, the averages are 0.31 and 0.99 during the first and second visits, respectively. Figure C.5 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.

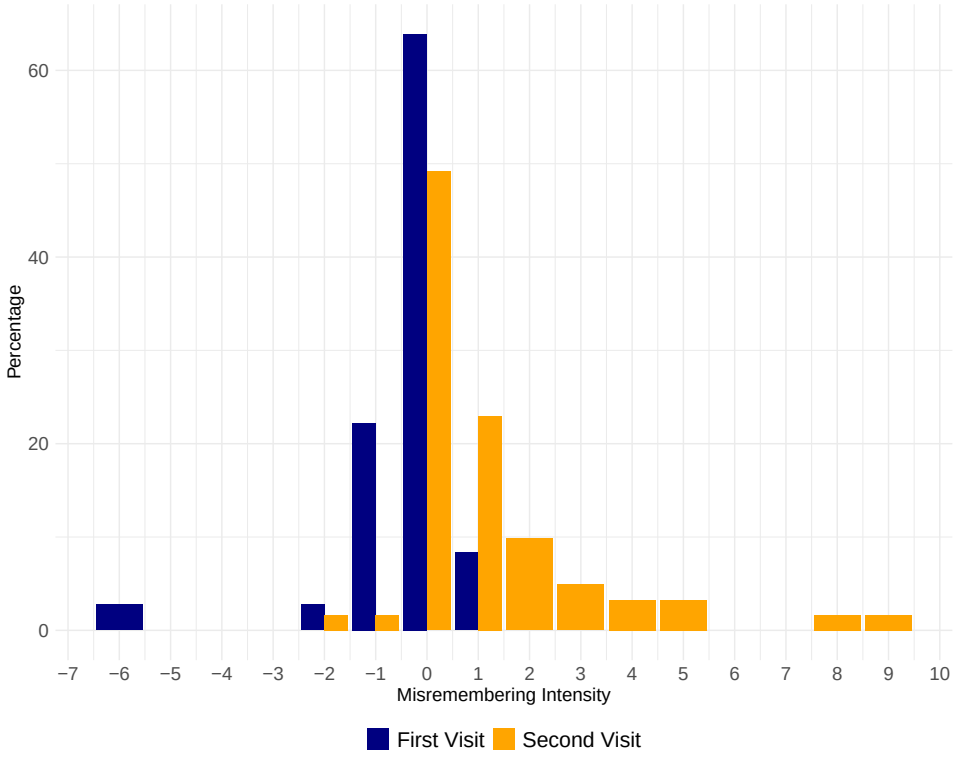

Figure C.5: Histogram of the intensities of misremembering during the first and second visits

Appendix C.4. Regression analysis - Dependent variable: motivated misremembering dummy

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Dummy of Misremembering					
Second visit	0.312**	0.128	0.128	0.314**	0.186	0.185
	(0.0961)	(0.122)	(0.121)	(0.0963)	(0.111)	(0.109)
Present bias dummy	0.250*	-0.158	-0.130			
	(0.0989)	(0.0857)	(0.135)			
P. bias x Second visit		0.550**	0.523**			
		(0.150)	(0.195)			
Present bias degree				0.0766**	-0.0456	-0.0434
				(0.0173)	(0.0251)	(0.0386)
P. bias degree x Second visit					0.144**	0.141**
					(0.0320)	(0.0484)
Female			0.115			0.130
			(0.112)			(0.108)
Mother has diploma			0.0557			0.0478
			(0.145)			(0.146)
Social rank			-0.0171			-0.00576
			(0.0323)			(0.0321)
Math			0.0228			0.0430
			(0.0521)			(0.0532)
Trust			0.0725			0.0482
			(0.0521)			(0.0561)
Risk attitude			0.0529			0.0407
			(0.0603)			(0.0585)
Constant	0.0481	0.158	-0.276	0.0564	0.150	-0.334
	(0.0787)	(0.0857)	(0.390)	(0.0731)	(0.0818)	(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<0.01, * p<0.05

Table C.7: OLS regression. Dependent variable: dummy for instance of misremembering.

Appendix C.5. Regression analysis - Dependent variable: motivated misremembering intensity

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Intensity of Misremembering					
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	-0.0771			
	(0.373)	(0.0857)	(0.341)			
P. bias x Second visit		0.649	0.655			
		(0.510)	(0.695)			
Present bias degree				0.349**	-0.0456	-0.0635
				(0.121)	(0.0251)	(0.0977)
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			0.0466			0.159
			(0.0972)			(0.0963)
Math			-0.362			-0.282
			(0.243)			(0.253)
Trust			0.243			0.223
			(0.244)			(0.161)
Risk attitude			0.122			0.0827
			(0.211)			(0.170)
Constant	0.0283	0.158	0.0958	-0.153	0.150*	-0.770
	(0.126)	(0.0857)	(1.376)	(0.149)	(0.0818)	(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<0.01, ** p<0.05

Table C.8: OLS regression. Dependent variable: Misremembering intensity

References

Amelio, A., Zimmermann, F., 2023. Motivated memory in economics—a review. Games 14, 15.

Augenblick, N., Rabin, M., 2019. An experiment on time preference and misprediction in unpleasant tasks. Review of Economic Studies 86, 941–975.

Bénabou, R., 2015. The economics of motivated beliefs. Revue d'économie politique 125, 665–685.

Bradford, D., Courtemanche, C., Heutel, G., McAlvanah, P., Ruhm, C., 2017. Time preferences and consumer behavior. Journal of Risk and Uncertainty 55, 119–145.

Brañas-Garza, P., Jorrat, D., Espín, A.M., Sánchez, A., 2023. Paid and hypothetical time preferences are the same: Lab, field and online evidence. Experimental Economics 26, 412–434.

Carlson, R.W., Maréchal, M.A., Oud, B., Fehr, E., Crockett, M.J., 2020. Motivated misremembering of selfish decisions. Nature communications 11, 2100.

Chew, S.H., Huang, W., Zhao, X., 2020. Motivated false memory. Journal of Political Economy 128, 3913–3939.

Cobb-Clark, D.A., Dahmann, S.C., Kamhöfer, D.A., Schildberg-Hörisch, H., 2024. Sophistication about self-control. Journal of Public Economics 238, 105196.

Cohen, J., Ericson, K.M., Laibson, D., White, J.M., 2020. Measuring time preferences. Journal of Economic Literature 58, 299–347.

Horn, D., Kiss, H.J., 2020. Time preferences and their life outcome correlates: Evidence from a representative survey. PloS one 15, e0236486.

Horn, D., Kiss, H.J., Lénárd, T., 2022. Gender differences in preferences of adolescents: evidence from a large-scale classroom experiment. Journal of Economic Behavior & Organization 194, 478–522.

Kim, K.R., Seo, E.H., 2015. The relationship between procrastination and academic performance: A meta-analysis. Personality and individual differences 82, 26–33.

Laibson, D., 1997. Golden eggs and hyperbolic discounting. The Quarterly Journal of Economics 112, 443–478.

Meier, S., Sprenger, C., 2010. Present-biased preferences and credit card borrowing. American Economic Journal: Applied Economics 2, 193–210.

O'donoghue, T., Rabin, M., 1999. Doing it now or later. American economic review 89, 103–124.

O'donoghue, T., Rabin, M., 2001. Choice and procrastination. The Quarterly Journal of Economics 116, 121–160.

Paserman, M.D., 2008. Job search and hyperbolic discounting: Structural estimation and policy evaluation. The Economic Journal 118, 1418–1452.

Sial, A.Y., Sydnor, J.R., Taubinsky, D., 2023. Biased Memory and Perceptions of Self-Control. Technical Report. National Bureau of Economic Research.

Takeuchi, K., 2011. Non-parametric test of time consistency: Present bias and future bias. Games and Economic Behavior 71, 456–478.

Wong, W.K., 2008. How much time-inconsistency is there and does it matter? evidence on self-awareness, size, and effects. Journal of Economic Behavior & Organization 68, 645–656.