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Abstract

Previous research consistently identified differences in time preferences between effort and monetary decisions. However, the root cause of this difference—whether it stemmed from the intrinsic nature of the outcomes or the associated pleasurable or unpleasurable experiences—remained undefined. In response, we devised a novel two-stage experiment employing a 2 × 2 design contrasting outcomes (money and effort) and domains (pleasant and unpleasant). This approach allowed for the incentivization of all decisions, including those involving future monetary losses. Our study reveals sign-dependent preferences, showing varying degrees of impatience across pleasant or unpleasant experiences in monetary or effort-related choices. We also observed outcome-dependent preferences, particularly highlighting a higher level of impatience in unpleasant monetary choices compared with their effort-based counterparts. However, the degree of present bias did not differ across the four conditions. (JEL: C91, D91)

Keywords: time preferences, losses, incentivized experiment

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1. Introduction

The study of time preferences has long held a central role in the exploration of individual decision-making. The understanding of time preferences has been the subject of rigorous investigation over the past decades (Abdellaoui et al., 2013; Andreoni & Sprenger, 2012; Frederick et al., 2002; Laibson, 1997; Thaler, 1981). The core result of these investigations is the separation of impatience (a long-term discount factor) and present bias (overvaluation of present outcomes) in time preferences, as demonstrated by the quasi-hyperbolic discount model by Laibson (1997), which has been instrumental in elucidating aspects of human behaviour.

Empirical investigation of time preferences has traditionally concentrated on those associated with time-dated monetary rewards (e.g., Ashraf et al., 2006; Dohmen et al., 2010; Tanaka et al., 2010). These preferences have been linked to behavioural patterns, such as credit card debt (Meier & Sprenger, 2010), body mass index (BMI) (Courtemanche et al., 2015), and impulse control disorders (Brewer & Potenza, 2008; Ida, 2014; Odum et al., 2002).

Previous literature has also unveiled more nuanced dimensions of time preferences. Evidently, they appear to be both sign-dependent (Benzion et al., 1989; Thaler, 1981) and outcome-dependent (Odum et al., 2006; Reuben et al., 2010). This underscores the importance of broadening the scope of investigation beyond merely monetary and pleasant outcomes to include non-monetary and unpleasant outcomes for a more comprehensive understanding of time preferences. Moreover, the potential effect of the fungibility of money has been discussed with an examination of the possible effect of the gap between the timing of receipt of money and its actual consumption (Cubitt & Read, 2007; O'Donoghue & Rabin, 2015). Consequently, recent studies (e.g., Augenblick et al., 2015; Augenblick & Rabin, 2019; Carvalho et al., 2016) have begun to examine effort-based choices because the time dedicated to specific tasks may serve as a more immediate reflection of consumption (Meissner & Pfeiffer, 2022). These studies show that individuals exhibit a more pronounced present bias in effort choices compared with monetary choices (see Imai et al., 2021, for a meta-analysis). However, monetary rewards and effort exertion are inherently different in types of outcomes and the associated experiences, whether pleasant or unpleasant. Consequently, the observed differences in present bias could be influenced by the type or sign of the outcomes or by a combination of both factors.

This research embarks on a methodologically rigorous experiment to investigate both the outcome- and sign-dependence of time preferences.

Added complexities arise, however, when considering the common practice of estimating those preferences in the loss domain through a hypothetical scenario (Thaler, 1981; Abdellaoui et al., 2013; Shiba & Shimizu, 2020), a method susceptible to *hypothetical bias*, which has been widely recognized in the literature (Abdellaoui et al., 2013; Shiba & Shimizu, 2020. See also Frederick et al., 2002). However, to our knowledge, no study has examined time preferences for monetary losses using incentivized experiments due to methodological and ethical challenges (detailed in the subsequent section). This study enables us to incentivize monetary losses building upon a previous elicitation method used in risky choices, to mitigate potential biases, including the hypothetical bias (Bosch-Domènech & Silvestre, 2010). Through a novel two-stage incentivized experiment, employing a 2 × 2 design contrasting outcomes (money and effort) and domains (pleasant and unpleasant), this study aims to clarify the outcome- and sign-dependence of time preferences.

Specifically, time preferences are elicited through intertemporal decisions involving monetary gains and task exemptions for pleasant outcomes, as well as monetary losses and added tasks for unpleasant outcomes. Distinct from previous research, all decisions in our experiment, including those related to future monetary losses, are incentivized. To streamline the transaction process, all monetary exchanges in this study were conducted through a mobile payment system, minimizing delays and ensuring smooth transactions as in Andreoni et al. (2018). Accordingly, this study offers significant contributions to the literature on time preferences, specifically catering to researchers interested in exploring loss domains through incentivized experiments.

Key findings from our research are as follows.

First, our results diverge from the conclusions drawn by Imai et al. (2021), who argued that individuals demonstrate a more pronounced present bias when making effort-related choices. We found no evidence of present bias in any of the four experimental conditions. Nevertheless, we observed that participants displayed more dynamically inconsistent preferences when making effort-related choices.

Second, our study revealed sign-dependence in impatience irrespective of whether the outcome involved money or effort. Intriguingly, the direction of this effect was opposite between the two. For monetary decisions, greater impatience was noted in the pleasant domain, aligning with the expected sign effect. Conversely, in decisions involving effort, a reverse sign effect was observed, with greater impatience in the unpleasant domain. This divergence suggests that the sign effect may not be universally applicable across different types of outcomes.

Third, we identified outcome-dependence in impatience. Namely, a notably higher level of impatience in unpleasant monetary choices was observed compared with their effort-based counterparts. Furthermore, effort-related choices tended to favour balanced allocations (i.e., demonstrated a preference for smoothness) over monetary choices.

The rest of the paper is organized as follows. The relevant literature is reviewed and the main hypotheses are formulated in Section 2. The design of the experiment is described in Section 3 followed by the results in Section 4. Section 5 summarizes the findings and offers some discussions.

2. Literature Review and Hypotheses

In this section, we review the existing literature pertinent to our study focusing on present bias, impatience, and their sign- and outcome-dependence. We also present our main hypotheses.

2.1. Present Bias

Present bias refers to the tendency to overvalue present outcomes, and it has become an integral concept within the realm of behavioural economics. This bias can be traced back to models of dynamically inconsistent time preferences, formulated by economists such as Strotz (1955), Laibson (1997), and O'Donoghue and Rabin (1999, 2001). Among these, the quasi-hyperbolic discount model has emerged as a particularly influential model (e.g., Laibson, 1997) because of its attractive analytical features (Frederick et al., 2002).

Numerous studies have reported evidence of present bias in human behaviour (e.g., Abdellaoui et al., 2013; Thaler, 1981). However, recent research employing innovative methods such as the convex time budget (CTB) method (Andreoni and Sprenger, 2012) yielded differing results. The CTB method, which allows for the simultaneous estimation of utility curvature and discount functions—including a parameter for present bias—has gained broad acceptance. Notably, the CTB method has led some studies to report a reduced degree of present bias or even an absence of it (e.g., Andreoni and Sprenger, 2012; Andreoni et al., 2015). A meta-analysis utilizing the CTB method, conducted by Imai et al. (2021), has shown a failure to reject the null hypothesis of no present bias for studies based on monetary choices.

The literature suggests that present bias may fluctuate based on contextual factors; however, precise mechanisms—such as whether it is sign-dependent—remain uncertain. Our literature review in the following sections aims to develop our hypotheses around the situational determinants of present bias. Notably, while the CTB method has been used to explore outcome-dependent present bias in a few studies, its use in investigating sign-dependent present bias is yet to be seen, to the best of our knowledge. Therefore, our literature review will encompass time preference studies utilizing various methodologies.

2.1.1. Sign-dependence of Present Bias. The investigation into present bias in pleasant and unpleasant domains is challenging. Previous literature on this subject is not only scarce but often inconsistent, thereby making conclusive interpretations elusive.

With regard to monetary choices, the body of research offers divergent insights. Thaler (1981) observed a marked decrease in discount rates as the timing of future gains was delayed, revealing a preference for present-biased behaviour within gains. However, this pattern was noticeably absent in the corresponding loss domain. Contrasting with Thaler's findings, more recent studies conducted by Shiba and Shimizu (2020) indicated that a significant portion of their participants exhibited present-biased preferences across both gain and loss domains. Furthermore, Abdellaoui et al. (2013) uncovered a more pronounced present bias in the context of monetary losses compared with gains. It is crucial to note that among these studies, no study provides incentives for both gain and loss domains.[1]

In the realm of effort choices, the literature is even more limited. To the best of our knowledge, Abdellaoui et al. (2018) conducted the only study comparing the level of present bias between gains and losses of working time and uncovering similar levels of present bias in both domains.

2.1.2. Outcome-dependence of Present Bias. Evidence suggests that individuals exhibit varying degrees of present bias for different outcomes. Bleichrodt et al. (2016) observed a stronger present bias for health outcomes compared with monetary ones. Cheung et al. (2022) reported a weaker present bias for food relative to money.[2] Studies for effort decisions (Augenblick et al., 2015; Augenblick & Rabin, 2019) indicated a higher degree of present bias in decisions involving effort than in those involving monetary gains. However, this body of research often does not account for the pleasantness or unpleasantness of the outcomes. Abdellaoui et al. (2018) performed the only study to compare present bias for monetary gains and gains of time, finding a greater bias for the latter. Furthermore, they found no significant correlation between present bias in monetary gains and gains of time. However, the scrutiny of effort and monetary

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[1] To the best of our knowledge, Yamamoto et al. (2020) performed the sole study that adequately incentivized time preferences across both gain and loss domains. However, this study encountered methodological challenges in accurately estimating time preferences.

[2] Cheung et al. (2022) noted a lesser present bias for food compared with money, despite employing the CTB method. They suggested that sample differences may influence outcomes.

decisions in the domain of unpleasant outcomes remains conspicuously unaddressed.

In summary, while there seems to be a general agreement that present bias is more pronounced in effort choices than in monetary choices, the degree to which this bias is influenced by sign or outcome remains unclear. Therefore, we propose the following hypothesis.

HYPOTHESIS 1: *A higher degree of present bias in the choices of effort exertion than the choices of monetary gain is observed.*

2.2. Impatience

The literature indicates that levels of impatience vary with context, yet definitive evidence to predict specific levels of impatience in distinct scenarios remains elusive—for example, the difference in impatience between monetary decisions and effort-based choices in an unpleasant domain. Our literature review in the following sections seeks to explore this variation to further formulate hypotheses on the contextual influences on impatience. Analogous to the discourse on present bias detailed previously, studies employing the CTB method to investigate both outcome- and sign-dependent impatience are notably limited. Thus, our review will cover a broad spectrum of time preference research employing diverse methodologies.

2.2.1. Sign-dependence in Monetary Choices. Several researchers have identified what is known as the *sign effect*, a pattern where future monetary gains tend to be discounted more heavily than losses (Benzion et al., 1989; Myerson et al., 2017; Thaler, 1981). This observation led to focused studies on money discounting, revealing that allowing the discount to change based on whether it involves gains or losses improves the description of time preferences (Abdellaoui et al., 2013; Scholten & Read, 2010).

The body of work related to the discounting of delayed gains is substantial and has been described by Harris (2012) as 'large and generally consistent'. By contrast, studies of the discounting of delayed losses appear more inconsistent and even contradictory.

An interesting aspect of this contrast is the tendency for zero or negative discounting with future small losses, a pattern not commonly observed with gains. For instance, Hardisty and Weber (2009) found varied behaviours in discounting delayed losses. Some of their participants showed the usual pattern of discounting delayed losses. However, others displayed negative discounting. Furthermore, Yoon and Chapman (2016) found that nearly all participants exhibited positive discounting of delayed monetary gains, whereas only 63% showed positive discounting of delayed losses, and notably, 11% showed negative discounting, choosing a larger, sooner loss over a smaller, later one.

2.2.2. Sign-dependence in Non-monetary Choices. In addition to Abdellaoui et al. (2018), who studied gains and losses of working time mentioned above, studies of the sign effect investigated non-monetary decisions. Specifically, Baker et al. (2003) observed that current smokers' delay discount rates for hypothetical cigarette outcomes were higher for gains than for losses, and these rates were also higher when evaluating cigarette outcomes compared with monetary outcomes. The sign effect has been identified in health outcomes as well (Baker et al., 2003; Chapman, 1996; MacKeigan et al., 1993), with Chapman (1996) discerning a more pronounced sign effect for health than for money. Yamamoto & Navarro-Martinez (2022) found a pronounced sign effect on consumer goods by demonstrating the absence of a discounting pattern in the future selling price of these goods. Furthermore, Hardisty & Weber (2009) extended the investigation of the sign effect to three domains—money, the environment, and health—demonstrating that the effect is consistent across all three, but is especially pronounced in the health domain.

In summary, the sign effect appears to manifest across different types of outcomes, including but not limited to monetary spheres. Furthermore, it seems to be more pronounced for non-monetary outcomes. Driven by these insights, we propose the following hypotheses.

HYPOTHESIS 2: *A higher degree of impatience is observed for pleasant outcomes than unpleasant outcomes in both monetary and effort choices.*

HYPOTHESIS 3: *The sign effect is more pronounced in effort choices compared with monetary choices.*

2.2.3. Outcome-dependence in the Pleasant Domain. A growing body of literature contrasts discount rates in monetary choices with those in primary rewards, such as food. The review by Cohen et al. (2020) indicates that the discount rate for monetary choices is generally lower than that measured for primary rewards, as corroborated by previous studies (Estle et al., 2007; Odum et al., 2006; Reuben et al., 2010; Tsukayama & Duckworth, 2010). Moreover, Tsukayama and Duckworth (2010) identified a positive correlation between temporal discounting of money and consumer goods. Cheung et al. (2022) report, once the present bias is controlled for, there is a significant difference between the discount rate for money and foods.

Abdellaoui et al. (2018) performed the only research specifically comparing impatience between decisions concerning monetary gains and choices regarding decreasing working hours. The results seemed to align with the finding of the relationship between money and consumer goods. They found that the median discount rate was higher for gains of time than for monetary gains, and impatience towards gains of working time and gains of money was highly correlated.

2.2.4. Outcome-dependence in the Unpleasant Domain. We anticipate that the level of impatience will be more pronounced in effort choices compared with monetary choices within the unpleasant domain. This expectation aligns with Hypothesis 3, wherein a higher sign effect is posited in effort decisions as opposed to monetary decisions.

Although no existing research directly contrasts time preferences between monetary and effort choices in the unpleasant domain, previous literature offers supporting evidence. Harris (2012) found that most participants preferred to postpone monetary losses, but intertemporal choices for other unpleasant experiences (such as social rejection, embarrassment, and pain) showed highly variable responses. Some participants deferred these experiences as long as possible, while many elected to experience them immediately. Baker et al. (2003) reported that health losses were discounted more slowly than monetary losses. Some other experimental studies have also noted negative discounting for health consequences (Ganiats et al., 2000; Van Der Pol & Cairns, 2000), as well as for electric shocks (Loewenstein, 1987; Yates & Watts, 1975).

Based on these observations, we formulate the following hypothesis.

Hypothesis 4: In both pleasant and unpleasant domains, a higher level of impatience is observed in effort outcomes than in monetary outcomes.

2.2.5. Hypothetical Intertemporal Decisions. We argue that our research uniquely approaches the proper incentivization of choices to elicit true underlying preferences across both gains and losses. A prominent aspect of research into the loss domain, specifically concerning time preferences, has been the reliance on hypothetical scenarios. This is also true for the studies introduced in Section 2. This method, while convenient, may introduce a phenomenon known as hypothetical bias (Frederick et al., 2002), whereby participants' responses to hypothetical questions may differ from their choices in real situations. Thus, a re-examination of even established phenomena like sign-dependent time preferences is warranted.

Hypothetical bias in the loss domain has been investigated in risk preference research. Weber et al. (2004) identified varying degrees of hypothetical bias in both gain and loss domains. If this is the case, then the extent of hypothetical bias could differ between time preferences for gains and losses, thereby skewing the analysis of the sign-dependency of time preference. Abdellaoui et al. (2013) explored time preferences for both monetary gains and losses but only incentivized the gains. Such an approach may bias the measurement of sign-dependent preferences. Therefore, comprehensive incentivization of all decisions, for both pleasant and unpleasant outcomes, is integral to the validity of this study.

As previously mentioned, addressing hypothetical bias in experiments involving potential monetary losses introduces challenges. The conventional method of providing an initial endowment to offset potential losses can inadvertently trigger the house-money effect (Thaler & Johnson, 1990). Estimating time preferences with windfall money could significantly distort the results. To mitigate this bias, Bosch-Domènech and Silvestre (2010) introduced an innovative approach: having participants earn money through unrelated tasks before commencing the main experiment. The foundation of this approach lies in the fact that money earned in this manner, and even taken home, is less likely to be viewed as house money. Bosch-Domènech and Silvestre (2010) supported this notion through post-experiment surveys. Leveraging this mechanism holds the potential to mitigate both hypothetical and house-money biases, thereby aiming to foster a more precise evaluation of participants' attitudes towards losses.

In light of these complex methodological challenges, our study introduces a two-stage experimental design. This approach aims to minimize both hypothetical and house-money biases by initially allowing participants to earn money to cover potential losses. Subsequently, participants return to engage in the main experimental session, involving intertemporal choices.

3. Experiment

We recruited 200 university students at Osaka University (35% female, age range: 18–36 years, with an average of 22.1 years). There were several conditions to participate in this study: having a PayPay account (mobile payment service that operates in Japan) and making transactions within 1 month; agreeing to participate in all sessions of the experiment lasting five weeks; and having a decent internet connection for participation in the experiment. The rewards depended on their decisions and the treatments that they were assigned to, but the average reward was 2,000 yen. Besides that, they received their preferred item, which was valued at around 5,000 yen, if they completed all sessions in the experiment.[3]

3.1. Design and Procedure

At the beginning of the experiment, participants were randomly divided into two treatments: Money and Effort. As detailed below, in the former, participants intertemporally allocated money, while in the latter, they allocated effort.

In both treatments, the experiment lasted 5 weeks, and participants needed to complete all sessions in Week 1 (the first day of the experiment), Week 3 (two weeks from the first day of the experiment), Week 4 (three weeks from the first day of the experiment), and Week 5 (four weeks from the first day of the experiment). In Week 5, all participants answered a set of questions related to their cognitive skills[4] and behaviour that are potentially correlated with their

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[3] On the first day of the experiment, we presented participants with a list of 30 attractive items. Participants were asked to rank these items in order of preference. The items were then distributed according to these rankings. A week after the experiment, the items were dispatched to the participants' designated locations. We opted for tangible items rather than money as completion rewards to minimize the likelihood of participants integrating them with the monetary rewards obtained during the experiment.

[4] Cognitive skills were measured by four Matrix reasoning items and four three-dimensional rotation items from The International Cognitive Ability Resource. In the three-dimensional rotation items, cubes were displayed at the top of the screen. Participants were tasked with selecting, from the given cube options, the one that could match the displayed cube when rotated. In the matrix reasoning items, a matrix featuring different geometric patterns—with one part missing—was displayed at the top of the

time preferences,[5] as well as demographics such as age, gender, and education. In addition, an attention check question was included to exclude inattentive participants from the experiment.

All sessions were conducted online, and all monetary transactions between the experimenter and participants were made via PayPay. Figure 1 shows the schedule over five weeks for the two treatments (for detailed experimental instructions, see Online Appendix). Let us describe each treatment in more detail.

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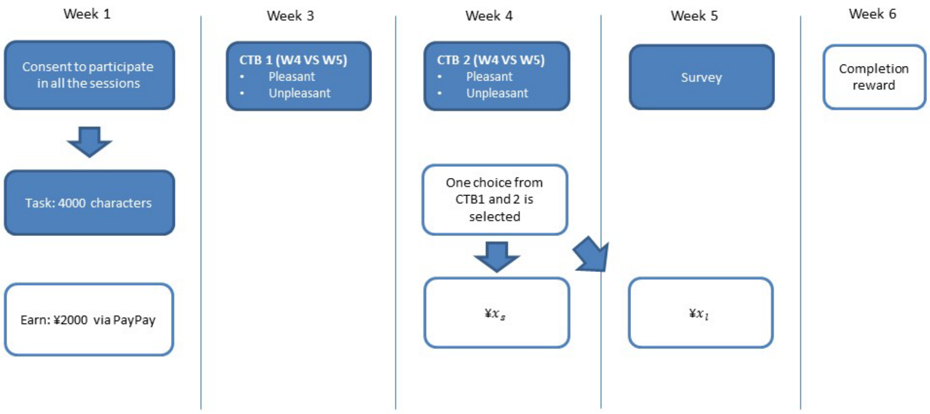
screen. Participants were tasked with selecting the most fitting geometric pattern from the given options to complete the missing part.

[5] Namely, questions about their drinking habits (Bradford et al., 2017): how many days they drink alcohol per month; how many times they drink large quantities per month (five drinks for men and four drinks for female), and how many glasses of alcohol they drink on average. We also asked other questions including how many times they played sport this year (less than once a month, 1–3 days per month, more than once a week, more than twice a week, more than three times a week, more than five times a week); if they feel they are usually healthy (I think very healthy, I think healthy, Not so healthy, Not healthy); their height and weight; their GPA; and the saving proportion of their monthly salary. In addition, we asked about their eating and shopping habits from the Shorter PROMIS Questionnaire (Christo et al., 2003).

A: Money treatment



B: Effort treatment

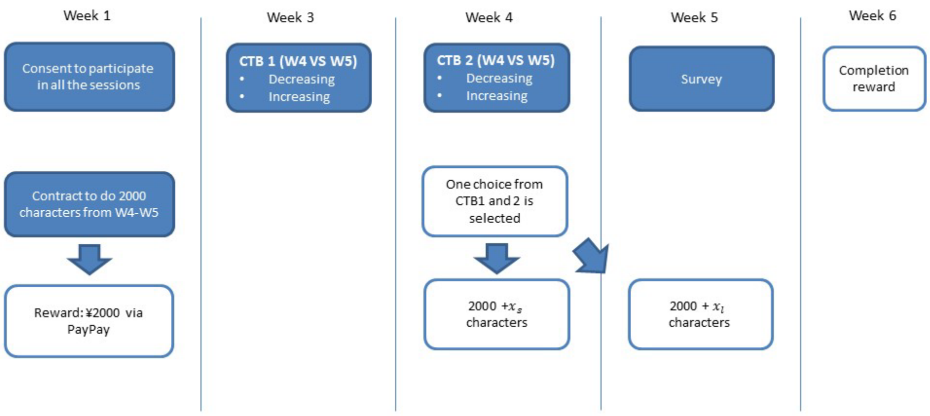


FIGURE 1. Experimental schedule for each treatment.

3.1.1. Money Treatment. The participants were asked to perform the task of transcribing 4,000 numbers on the screen in Week 1. Each page of this task displayed ten blurred numbers that needed to be transcribed (see Figure for an example). Thus, participants needed to complete 400 pages, and they received a reward of 2,000 yen for doing so. This reward was designed to offset any potential losses in subsequent sessions. The participants were informed that the reward is the participants' own payment and can be used anytime. To ensure that participants understood the payment procedure and rules, they needed to correctly answer the comprehension question before proceeding to the experiment.

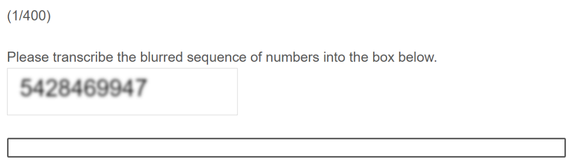


FIGURE 2. Screenshot of an example for the transcription tasks (translated in English).

In Weeks 3 and 4 (the second and third sessions), participants made a total of 36 intertemporal allocation choices. There were two sets (Sets 1 and 2) of nine questions for gains (pleasant domain) and nine questions for losses (unpleasant domain). In Set 1, participants faced allocation problems with a budget constraint,

$$(1 + R)x_s + x_l = B$$

where x_s and x_l are the amounts of outcome and B is a (future-value) budget. The set of questions is constructed with nine different interest rates: R = –0.3, –0.18, –0.07, 0, 0.11, 0.25, 0.43, 0.67, and 1 with $B = 1000$. Set 2 employed a budget constraint of

$$x_s + \frac{1}{1+R} x_l = B$$

with parameters R = –0.34, –0.21, –0.09, 0, 0.07, 0.25, 0.38, 0.6, and 0.9 and $B = 800$.

We based the format of our CTB questions on Cheung et al. (2022). Namely, participants chose one option from nine equally split bundles on the budget line as shown in Figure 2. Furthermore, to maintain equal transaction costs between sooner and later dates, we avoided using corner bundles of zero for either the sooner or later dates from the choice set (i.e., $x_s = 0$ or $x_l = 0$). The minimum values for x_s and x_l were set at 5 in both Sets 1 and 2.

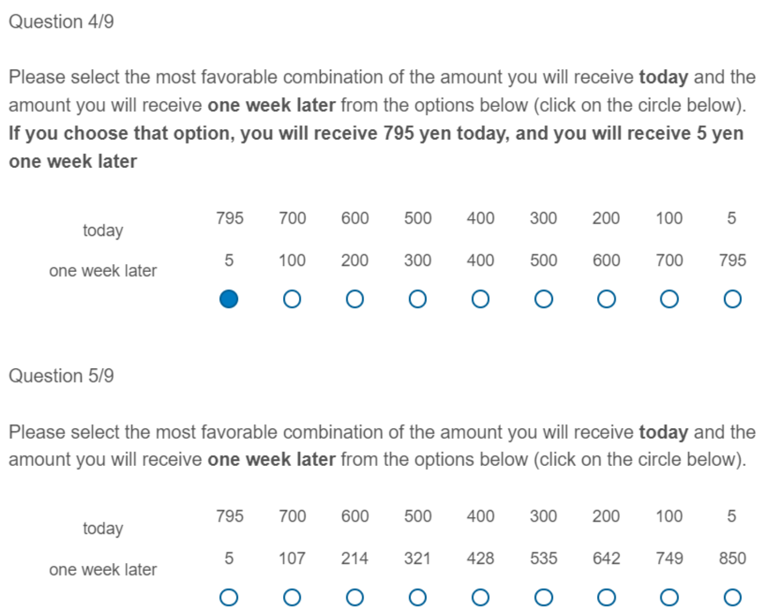


FIGURE 2. English translation of the screenshots of the allocation decisions in Week 4: gain (pleasant domain) of monetary choices with R = 0 (top) and 0.07 (bottom).

The participants would receive x_s and x_l in the pleasant domain, and the participants would pay x_s and x_l in the unpleasant domain. We did not explicitly show the interest rate to the participants. They can allocate the budget disproportionately more to the sooner period (e.g., the far-left options in Figure

2), disproportionately more to the later period (e.g., the far-right options in Figure 2), or in between.

In the example questions shown in Figure 2, the payments on the sooner dates always decrease from the left to the right options (refer to Figures A1, A2, and A3 for example questions in the other treatments). To avoid the order effect, we created another version in which the payments on the sooner dates always increase from the left to the right options by flipping the order of the questions. One of the two versions was randomly shown to the participants. In addition, the order of the pleasant and unpleasant domains was randomized.

In Week 3, participants chose the allocations between Weeks 4 and 5. The sooner date is one week after the date of the allocation decisions, making these questions front-end-delay questions. In Week 4, they again faced the same allocation problems between Weeks 4 and 5. However, this time the sooner date coincided with the day of the intertemporal decisions, rendering these as no front-end-delay questions. Comparing the decisions in these two types of questions allows us to assess their level of present bias.

Subsequently, one question was randomly selected from all questions answered in Weeks 3 and 4. The monetary transaction was carried out based on the participant's decision in the selected question. If the selected question was about the choices regarding monetary gains, they would receive x_s in Week 4 and x_l in Week 5. If the selected question was about the choices regarding monetary losses, they would pay x_s in Week 4 and x_l in Week 5.

We again asked the comprehension quiz about the instructions to make sure participants understand how the allocation problems work before making the allocation decisions in both Weeks 3 and 4. They could not go to the next page until they chose the right answer in each quiz.

3.1.2. Effort Treatment. In Week 1, participants agreed to perform the task of transcribing 2,000 random numbers in both Weeks 4 and 5 and received 2,000 yen as compensation for doing so. As in the money treatment, they were informed that this compensation was their own payment, and they also answered the comprehension question about it. To underscore the commitment, we had them sign a document detailing the contract and return it to us. The purpose of this contractual agreement was to enhance the salience of the effort's reference points and encourage participants to integrate it.[6] The intertemporal decisions in this treatment mirrored those of the money treatment. In each of Weeks 3 and 4, participants answered a total of 36 allocation questions regarding the amount of tasks in Weeks 4 and 5. The amount of numbers to transcribe was reduced in the pleasant domain, while it was increased in the unpleasant domain. Namely, participants had to transcribe $2000 + x_s$ and $2000 + x_l$ numbers in Weeks 4 and 5, respectively. In each question, participants chose one option from nine equally split bundles on the budget line.[7]

One question was later randomly selected from all questions answered during Weeks 3 and 4 to determine the actual workload. If a pleasant one was chosen, x_s and x_l would be negative, while if an unpleasant one was chosen, x_s and x_l would be positive. The bundles of x_s and x_l, as well as the budget

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[6] The analyses presented in Appendix C indicate that this was indeed successful.

[7] This contrasts with the approach of Augenblick et al. (2015), who employed a slider-type question for effort allocation decisions. However, our analysis, transforming the experimental data of Augenblick et al. (2015) into a format analogous to our discrete choice framework, revealed that the results were similar. This comparative analysis is available upon request.

constraints (R and B), are identical between the two treatments, ensuring that the decisions are comparable.

3.2. Measurements of Time Preference

We measure the participants' time preferences using choice-based indices. These descriptive measures are based on simple proportions of rewards allocated to sooner versus later payment dates. By employing such descriptive measures, the study aims to provide evidence regarding the behaviours of interest without relying on specific functional forms. The literature establishes that time preference can be decomposed into three distinct properties: impatience, present bias, and a preference for smoothing (Frederick et al., 2002). We follow Cheung et al. (2022) to measure these properties in the four conditions: pleasant monetary outcomes (Money-pleasant), unpleasant monetary outcomes (Money-unpleasant), pleasant effort outcomes (Effort-pleasant), and unpleasant effort outcomes (Effort-unpleasant).

Impatience describes the extent to which individuals discount delays, essentially measuring their willingness to wait for future outcomes. Impatience for pleasant outcomes is measured by the average proportions allocated to the sooner option in Week 3, the initial intertemporal decisions with front-end-delay. This is calculated as $Impatience = mean\left(\frac{x_s}{x_s+x_l}\right)$, where x_s and x_l are the sooner and later allocations at each decision problem, respectively. *Impatience* equals 1 if the participant always allocates all resources (the number of exempted tasks in Effort-pleasant) to the sooner dates (extremely impatient) and 0 if they always allocate them to the later dates (extremely patient).[8] For unpleasant outcomes, the proportion of outcomes allocated to later dates serves as an indicator of impatience, computed as $Impatience = mean(\frac{x_l}{x_s+x_l})$. This is based on the rationale that an impatient individual would prefer to postpone unpleasant outcomes to later dates.

Present bias (PB) indicates the extent to which individuals overweigh present outcomes. Present bias is measured by the difference between allocations at two periods, i.e., $PB = mean(\frac{x_s}{x_s+x_l}|_{at\ w4} - \frac{x_s}{x_s+x_l}|_{at\ w3})$ in the pleasant domains and $PB = mean(\frac{x_l}{x_s+x_l}|_{at\ w4} - \frac{x_l}{x_s+x_l}|_{at\ w3})$ in the unpleasant ones. PB describes how much the allocations have changed from the questions with front-end-delay to those without. It takes values between –1 (extremely future-biased) and 1 (extremely present-biased).

Preference for smoothing (*Smooth*) describes how individuals prefer equal allocations between sooner and later dates. It is defined as $Smooth = mean(\frac{(x_s+x_l)-|x_s-x_l|}{x_s+x_l})$ for both pleasant and unpleasant outcomes. It takes values between 0 (smoothing hater) and 1 (smoothing lover).

In addition to these descriptive measures, we employ an auxiliary method that utilizes the quasi-hyperbolic discounted utility model of Laibson (1997) with the Constant relative risk aversion (CRRA) utility function to yield clearer differentiations among parameter values. Namely, we assume the utility from the

[8] Note that the exclusion of corner bundles from our choice sets means that our descriptive measures, *Impatience*, do not reach these theoretical extremes in our experimental design. The same applies to *PB* and *Smooth*, which are defined in this section.

alternative in the CTB questionnaire (x_s, x_l) is $U(x_s, s_l) = D(t_s)U(x_s) + D(t_l)U(x_l)$ where the discount function $D(.)$ and instantaneous utility $U(.)$ are $D(t) = \beta^{1_{t>0}}\delta^t$ and $U(x) = u(x)$ for $x > 0$ and $U(x) = -u(-x)$ for $x < 0$, respectively, with

$$u(x) = \begin{cases} \frac{x^{1-\alpha}}{1-\alpha} & (\alpha \neq 1) \\ \ln(x) & (\alpha = 1) \end{cases}.$$

This model allows for the joint estimation of three crucial parameters: the weekly discount factor (δ), present bias (β), and utility curvature (α), using the maximum likelihood estimation (MLE) with the multinomial logit probability of a specific choice

$$\Pr(choice) = \frac{e^{U^*/s}}{e^{U^1/s} + e^{U^2/s} + \cdots + e^{U^9/s}}$$

where $U^1, U^2, \ldots, U^9$ are utilities of the nine alternatives in a choice set under $\delta, \beta,$ and α, and s is a noise parameter in each choice. U^* is the utility of the chosen alternative.[9]

[9] In alignment with the methodology set forth by Cheung et al. (2022), we imposed bounds on the estimates for δ, β, and α within the ranges of 0.1 to 10, 0.05 to 20, and –10 to 10, respectively. The number of subjects whose estimated parameters approached the boundary (within a distance of 0.001) was as follows: zero out of 89 for both pleasant and unpleasant domains in the monetary choices. In the effort choices, the numbers were 14 and 12 out of 76 for the pleasant and unpleasant domains, respectively. A further breakdown in the effort condition revealed that four and three subjects approached the boundary for δ, 11 and eight subjects for β, and zero and one subject for α in the pleasant and unpleasant conditions, respectively.

TABLE 1. The summary table of demographic and behavioural variables.

Variables	Money Mean	SD	Effort Mean	SD	t	p	N
Age	22.00	(2.15)	22.32	(3.06)	–0.77	(0.44)	87
Female	0.39	(0.49)	0.30	(0.46)	1.21	(0.23)	89
College	0.36	(0.48)	0.25	(0.44)	1.52	(0.13)	89
BMI	21.52	(4.89)	21.23	(2.58)	0.46	(0.64)	88
GPA	2.93	(0.53)	2.95	(0.64)	–0.20	(0.84)	83
Saving_rate	28.99	(24.91)	33.75	(24.22)	–1.24	(0.22)	89
Matrix_score	1.96	(1.12)	1.74	(1.16)	1.23	(0.22)	89
Rotation_score	0.82	(1.14)	0.86	(1.05)	–0.20	(0.84)	89

Notes: 'Saving_rate' refers to the proportion of the monthly salary that participants saved. 'Matrix_score' represents the scores derived from four matrix reasoning items. 'Rotation_score' captures the scores from four assessments involving three-dimensional rotation tasks.

4. Results

A total of 184 participants took part in Week 1. Of these, 13 participants withdrew during the course of the experiment, and an additional five failed to complete transactions correctly. One participant who did not pass our attention check was also excluded. Consequently, our analysis includes 165 participants who successfully completed all sessions.

Table 1 outlines the demographic and other pertinent characteristics of the participants between the two treatments, highlighting selected variables; a comprehensive list of other variables is available in Table A.2 in the Appendix. The values of the variables do not differ between the treatments (t-test, all p-values greater than 0.1).

4.1. Descriptive Analysis

Figure reports the mean proportions of allocations (Money-pleasant, Money-unpleasant, Effort-pleasant, and Effort-unpleasant) and their standard errors to sooner dates for each condition.[10] The left side of Figure shows the results of Set 1 and the right side of Figure shows the results of Set 2. The overall patterns between the two sets are similar, implying that preferences were not affected much by the two different budget sets. The proportion of allocation to sooner dates decreases as R increases in pleasant conditions, while the proportion to later dates increases as R increases in unpleasant conditions, consistent with the law of demand.

[10] The proportion of the allocation is calculated by $1 - X_l/B$ for Set 1 and X_s/B for Set 2.

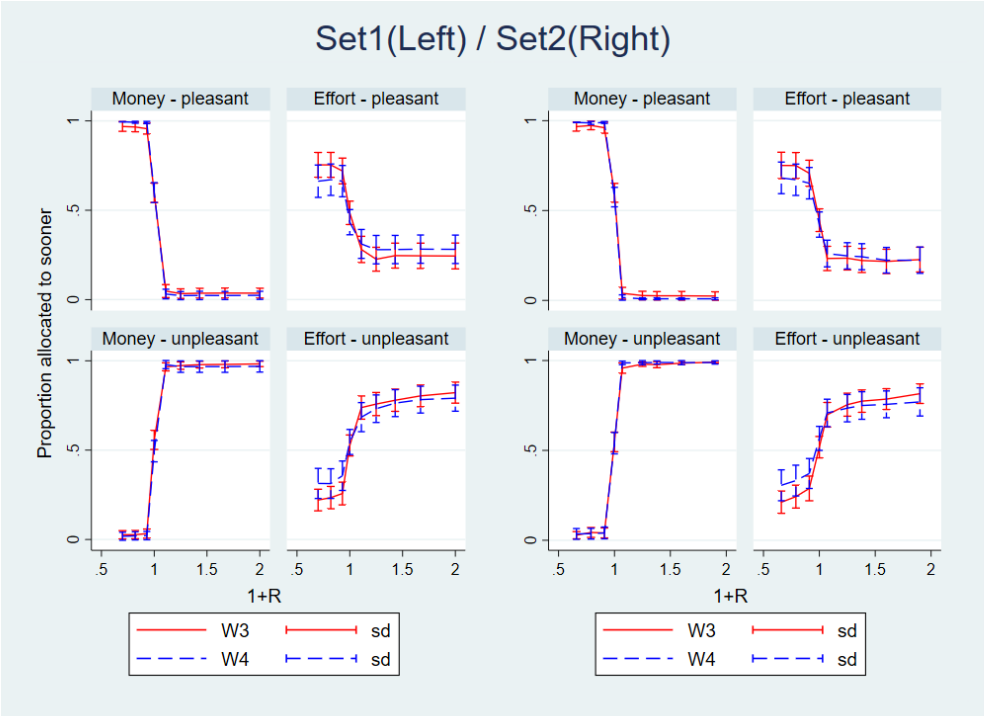


FIGURE 4. Proportions of allocations in the four conditions for Set 1 (left) and Set 2 (right).

NOTE: The solid lines indicate the proportion of the allocations in Week 3, and the dotted lines indicate the proportion of the allocations in Week 4. Each bar describes the standard error.

Table 2 reports the descriptive measures in the four conditions. The mean *Impatience* ranges from 0.39 to 0.44 in all conditions, indicating that our participants allocated a significant amount to the later (sooner) dates when allocating pleasant (unpleasant) outcomes. The median value of *Impatience* for monetary gains in Cheung et al. (2022) is 0.39, which is close to our value, indicating our results in this condition are compatible with the previous finding. The solid lines in Figure 4 describe the allocations in Week 3 (with front-end-delay), and the dotted lines describe the allocations in Week 4 (no front-end-delay). In the pleasant condition, present-biased subjects are expected to allocate more pleasant outcomes to the sooner date in Week 4; thus, the dotted lines would be above the solid lines. In the unpleasant conditions, present-biased subjects are expected to allocate more unpleasant outcomes to the later date in Week 4; thus, the dotted lines would be below the solid lines. However, we do not clearly see such patterns in either treatment. Indeed, the mean *PB* is nearly zero in all four conditions (t-test, all p-values greater than 0.1), indicating that our participants' allocation remained unchanged from Week 3 to Week 4 on average. This outcome, highlighting the absence of present bias in monetary choices, aligns with preceding studies. However, the lack of present bias in effort choices counters established literature on the topic (Imai et al., 2021).

RESULT 1: *Present bias is not observed in either the effort or monetary choices.*

TABLE 2. The summary statistics of descriptive measures, by condition.

	(1) Money-Pleasant mean/sd/p50	(2) Money-Unpleasant mean/sd/p50	(3) Effort-Pleasant mean/sd/p50	(4) Effort-Unpleasant mean/sd/p50
Impatience	0.41	0.39	0.42	0.44
	(0.04)	(0.04)	(0.16)	(0.17)
	0.39	0.39	0.39	0.41
PB	–0.00	0.00	–0.01	–0.02
	(0.04)	(0.07)	(0.22)	(0.21)
	0.00	0.00	0.00	0.00
Smooth	0.10	0.11	0.31	0.35
	(0.07)	(0.10)	(0.28)	(0.30)
	0.12	0.12	0.15	0.30
N	89	89	76	76

By contrast, the standard deviations for *PB* in the Effort treatment are significantly larger in both pleasant and unpleasant domains than in the Money treatment (F-test, $p < 0.001$ in both domains), indicating considerable heterogeneity among participants' *PB* in effort choices. Moreover, Table 3 describes the frequencies of present-biased, future-biased, and neutral (*PB* = 0) participants. In the Effort treatment, only 21% of observations are categorized as neutral in both pleasant and unpleasant domains, whereas in the Money treatment, 58% of observations in the pleasant domain and 50% in the unpleasant domain are classified as neutral. These suggest a higher level of dynamic inconsistency in effort choices. In the pleasant domain, the proportion of present-biased participants is noticeably higher in Effort than in Money. Conversely, in the unpleasant domain, the proportion of present-biased individuals does not show a substantial difference between the two treatments.

TABLE 3. Present-biased and future-biased individuals.

		Present-biased	Neutral (PB = 0)	Future-biased	Total
Money	Pleasant	19 (21.35%)	52 (58.43%)	18 (20.22%)	89 (100%)
	Unpleasant	26 (29.21%)	45 (50.56%)	18 (20.22%)	89 (100%)
Effort	Pleasant	37 (48.68%)	16 (21.05%)	23 (30.26%)	76 (100%)
	Unpleasant	24 (31.58%)	16 (21.05%)	36 (47.37%)	76 (100%)

Next, we examine the preference for smoothness. As depicted in Figure , almost all outcomes were allocated to the sooner date when (1 + R) was less than 1 and allocated to the later date when (1 + R) was more than 1 in the Money treatment. However, a less extreme pattern is found for the Effort treatment, with the allocation to the sooner date gradually decreasing as R increased. A similar pattern was observed for the unpleasant conditions. The sooner allocation progressively increased as R rose, while in the Money treatment, nearly all monetary losses were allocated to the later date when 1 + R was less than 1 and to the sooner date when 1 + R was more than 1. This trend is further supported by the smoothness index. The mean value of *Smooth* was approximately 0.1 in

Money and 0.3 in Effort (see Table 2). This indicates a higher inclination towards balanced allocations in the effort choices compared with the monetary ones, providing evidence of a greater preference for smoothness in the former.

TABLE 4. The mean differences of the three descriptive measures.

	(1) Pleasant-Unpleasant (Money)	(2) Pleasant-Unpleasant (Effort)	(3) Money-Effort (Pleasant domain)	(4) Money-Effort (Unpleasant domain)	(5) Gains of Money-Additional Effort
Impatience	0.02***	–0.02**	–0.01	–0.06**	–0.04*
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
PB	0.00	0.01	0.01	0.03	0.02
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Smooth	–0.01	–0.04***	–0.21***	–0.24***	–0.25***
	(0.01)	(0.02)	(0.03)	(0.03)	(0.03)
N	178	152	165	165	165

Notes: Standard errors in parentheses; *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

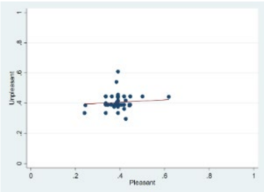
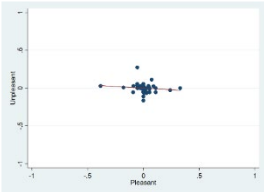
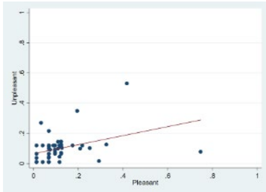
4.1.1. Sign-dependent Preferences. To examine sign-dependent preferences, we used our descriptive measures to compare the pleasant and unpleasant domains within the monetary or effort choices to avoid any unnecessary confounds. The findings are presented in Columns (1) and (2) of Table 4.

Participants displayed greater impatience for pleasant outcomes compared with unpleasant ones in the Money treatment (paired t-test, p = 0.002), consistent with the sign effect (Frederick et al., 2002).

Sign-dependence was also observed in the Effort treatment (p = 0.03), but surprisingly, participants exhibited greater impatience in the unpleasant domain compared with the pleasant domain. This finding contradicts the sign effect and does not support Hypotheses 2 or 3. By contrast, no evidence of sign-dependent preferences in *PB* was found in either treatment (p = 0.62 in the Money treatment and 0.58 in the Effort treatment). *Smooth* in the unpleasant domain was larger than in the pleasant domain in the Effort treatment (p = 0.006), but the difference was not significant in the Money treatment (p = 0.22).

A: Money treatment

Impatience ($\rho = 0.09$) PB ($\rho = -0.14$) Smooth ($\rho = 0.39$)

B: Effort treatment

Impatience ($\rho = 0.83$) PB ($\rho = 0.77$) Smooth ($\rho = 0.89$)

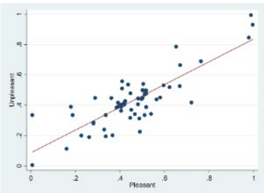
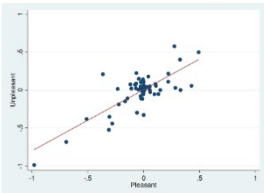
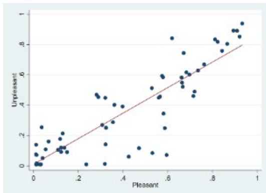




FIGURE 5. Indices of time preferences based on descriptive measures in money (top) and effort (bottom).

Note: The values in the pleasant domain are shown on the x-axis, and the values in the unpleasant domain are shown on the y-axis. The dots represent observations. The red lines describe the fitted lines

Given that participants answered the questions in both pleasant and unpleasant domains, we can examine the relationship between these domains at the individual level. Figure 5 shows the correlation between the two domains for each index in both treatments. In the Money treatment, there is no clear correlation for any of the indices between the two domains, suggesting that time preferences for monetary gains and losses are almost independent of each other. By contrast, each index in the Effort treatment shows a strong positive correlation between the two domains, indicating that preferences are similar across both domains when it comes to effort choices. Furthermore, the values for each index are much more dispersed for Effort, reflecting considerable heterogeneity in the effort choices as noted above.

RESULT 2: *While the sign effect finds empirical support in monetary choices, a surprising reversal of the sign effect emerges in effort choices, partially supporting Hypothesis 2 but not supporting Hypothesis 3. No evidence of sign-dependent present bias was found in either type of choice.*

4.1.2. Outcome-dependent Preferences. Next, we compare indices in monetary choices with those in effort choices within either the pleasant or unpleasant domains as shown in Columns (3) and (4) of Table 4.

Impatience between monetary and effort choices is not significantly different in the pleasant domain (t-test, p = 0.4). By contrast, *impatience* in monetary choices is significantly higher than in effort choices within the unpleasant domain (p = 0.003).

RESULT 3: *While impatience levels in monetary and effort choices are statistically indistinguishable in the pleasant domain, monetary choices in the unpleasant domain exhibit significantly higher impatience levels compared with effort choices. Consequently, these findings do not lend support to Hypothesis 4, which had posited greater levels of impatience in effort-based choices.*

In addition, *Smooth* is higher for effort choices than for monetary choices ($p < 0.001$ in both domains). Importantly, we do not identify outcome-dependent preferences in terms of *PB* in either the pleasant or unpleasant domains ($p = 0.58$ and 0.26, respectively).

In Column (5) of Table 4, we additionally compare preferences between the Money-pleasant and Effort-unpleasant conditions as in Augenblick et al. (2015). *PB* is not significantly different between these conditions, thereby failing to support Hypothesis 1. *Impatience* is higher ($p = 0.04$) and *Smooth* is significantly higher ($p < 0.001$) in the Effort-unpleasant than in the Money-pleasant condition. These results do not match the previous findings that there is a lower estimated present bias β and a higher discount factor δ in the Effort-unpleasant condition compared with the Money-pleasant condition (Augenblick et al., 2015).

4.2. Parameter Estimations

Next, we report the results of our parameter estimations of the quasi-hyperbolic model with CRRA utility function at the individual level.[11] Overall, the findings are consistent with those based on descriptive measures reported above.

[11] We conducted an aggregate analysis as well, which is presented in Appendix A.

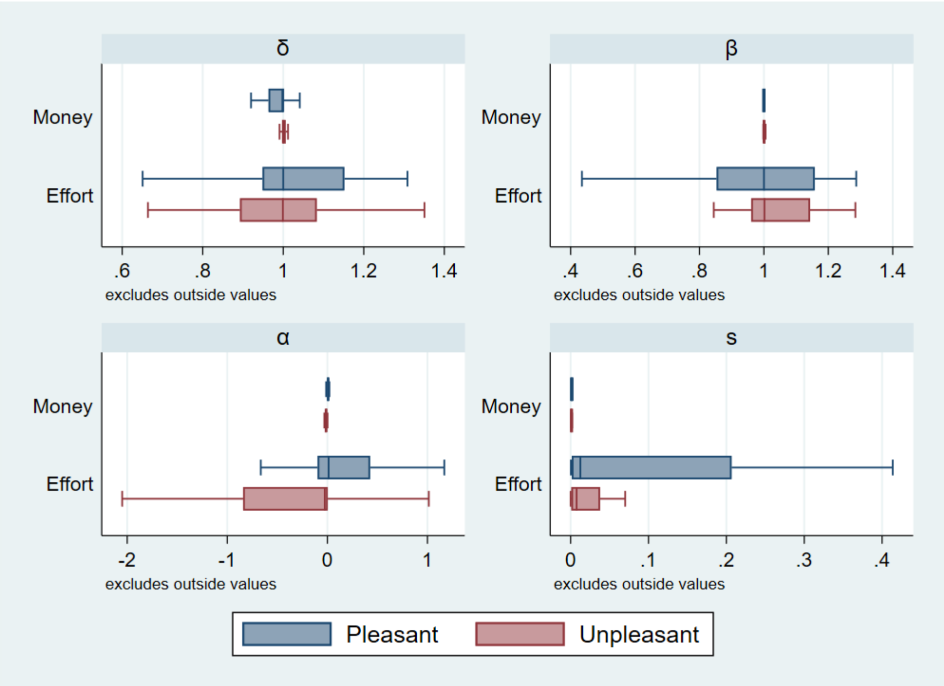


FIGURE 6. Boxplots for each parameter from MLEs.

Note: The left and right edges of each box indicate the first (Q1) and third quartiles (Q3), respectively. The line within the box represents the median. Outliers, identified as values falling below Q1 minus 1.5 times the interquartile range (IQR) or above Q3 plus 1.5 times the IQR, have been excluded in accordance with Tukey's rule.

The results are summarized in Figure . We found the medians of δ and β to be one across the four conditions. The interquartile ranges are larger in the Effort treatment than the Money treatment for all parameters, indicating a more pronounced heterogeneity in the Effort treatment than in the Money treatment (Brown–Forsythe test; $p < 0.001$ in both the pleasant and the unpleasant domains). The results suggest a greater prevalence of time-inconsistent behaviours in decisions involving effort.

In both treatments, the median value of α is negative in the unpleasant domain, indicating that the utility function of our participants is concave (sign-rank test; $p = 0.02$ in the Money treatment and $p = 0.001$ in the treatment Effort). In the pleasant domain, the median values of α are positive but not significantly different from 0 in both treatments ($p = 0.21$ in the Money treatment and $p = 0.15$ in the Effort treatment). The small interquartile range of α in the monetary choices indicates little heterogeneity regarding utility curvature. These results for the utility curvature are consistent with Abdellaoui et al. (2013) and Abdellaoui (2018).

We also tested for sign-dependent preferences using the sign-rank test. First, δ is significantly different between the two domains for monetary choices ($p = 0.02$) and marginally different for effort choices ($p = 0.07$). However, β is not significantly different between the two domains in both treatments ($p = 0.97$ in the Money treatment and 0.42 in the Effort treatment). The difference in α between the two domains is not significant for monetary choices ($p = 0.5$), but the difference is marginally significant for effort choices ($p = 0.08$).

The correlation between domains, in monetary choices, δ and β is not strong ($\rho = 0.1$ and –0.02, respectively). However, in effort choices, these parameters show a moderate positive correlation ($\rho = 0.53$ for δ and $\rho = 0.69$ for β).

Next, we examine outcome-dependent preferences using the Mann–Whitney test. α is significantly different between the two types of outcomes in both domains ($p = 0.003$ in the Money treatment and $p < 0.001$ in the Effort treatment), thereby confirming that utility curvature varies between monetary and effort choices in the pleasant domain. δ shows a significant difference between outcomes only in the pleasant domain ($p = 0.02$ for pleasant and $p = 0.18$ for unpleasant). Finally, β exhibits no significant difference between outcomes in either domain ($p = 0.72$ in the pleasant domain and 0.15 in the unpleasant domain).

4.3. Preference as a Predictor of Economic Behaviours

We now shift our focus to the relationship between specific indicators of time preference—for both money and effort across pleasant and unpleasant domains—and behaviours outside of the experimental setting. These behaviours were elicited through the questionnaire administered in Week 5, across varying conditions and domains.

For our analysis, we selected those behaviours that have previously been shown to correlate with experimentally measured time preferences, such as alcohol use (Bradford et al., 2017; Sutter et al., 2013; Vuchinich & Simpson, 1998), savings (Angeletos et al., 2001; Bradford et al., 2017; Sutter et al., 2013), educational attainment (Duckworth & Seligman, 2005; Falk et al., 2018; Reed & Martens, 2011), and exercise (Bradford, 2010; Bradford et al., 2017). We also included behaviours intuitively linked to time preferences but with non-significant correlations, such as the percentage of income saved (Chabris et al., 2008), as well as those with mixed results, BMI (Barlow et al., 2016; Cheung et al., 2022).

Bartels et al. (2023) examine a wide range of behaviours and suggest their correlations with experimentally measured discount rates are frequently modest and sometimes even negligible. A plausible reason for this limited correlation is the methodology used both by Bartels et al. (2023) and many earlier studies listed above. Specifically, these studies predominantly employ choices involving monetary gains to measure time preferences. However, most real-world intertemporal choices encompass diverse outcomes and domains, for example, when choosing to exercise involves short-term effort for long-term health benefits.

As our analyses have demonstrated, time preferences are both outcome- and sign-dependent, and they display significant heterogeneity at the individual level. Therefore, some behaviours may correlate with experimentally measured time preferences only when considering particular outcome choices within specific domains.

We employ multiple linear regression to analyse behaviour, using the estimated time preference parameters δ and β as predictors and demographic variables as controls.[12]

Our analysis reveals notable correlations between measured time preferences and behaviours such as eating habits, BMI, and academic performance. Table 5 indicates that the patience parameter, δ, among Effort-pleasant conditions, is negatively correlated with BMI. That is, individuals with a higher level of patience have smaller BMI. However, these parameters from monetary choices show no significant correlation with BMI. This contrasts with Cheung et al. (2022), who found that for money and unhealthy food, less patient individuals, and those less present biased towards healthy food, had lower BMIs. Furthermore, β in the Money-unpleasant condition is negatively correlated with binge eating, a correlation not observed for βs estimated under the other conditions. This suggests that individuals who are more inclined to under weigh future payments are also prone to binge eating.

We also found that δ in effort-based decisions is positively correlated with grade point average (GPA), whereas its monetary counterpart is not. This observation suggests that a greater level of patience in effort-related decisions is indicative of higher academic performance. This conclusion is not entirely

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[12] We employed age, age squared, and two dummy variables indicating female and graduate students as our control variables.

aligned with previous results (e.g., Cheung et al., 2022) that show a positive correlation between patience in monetary choices and grades.

Some behaviours, such as saving rates and health behaviours, showed weak or no correlation with measured time preferences in our study. In addition, some findings are counterintuitive. For example, both δ and β in the unpleasant-monetary condition are negatively correlated with sports engagement. Moreover, we observe a positive correlation between δ in the Effort-pleasant condition and alcohol-related behaviours. This result is incongruent with the study of Vuchinich and Simpson (1998), who demonstrated a significant relationship between temporal discounting rates for financial rewards and heavy drinking. These results imply that time preference parameters may not be robust predictors for certain behaviours, aligning with the findings of Bartels et al. (2023), even when outcome- and sign-dependence in time preferences are taken into account.

TABLE 5. Relationship between δ and β, and self-reported everyday behaviours.

	Money-pleasant		Money-unpleasant		Effort-pleasant		Effort-unpleasant	
Saving_rate								
δ	35.22	(41.39)	85.83	(81.05)	2.04	(1.60)	0.30	(2.15)
β	1.67	(20.60)	15.23	(14.41)	-0.46	(0.50)	-0.16	(0.53)
BMI								
δ	-3.99	(5.07)	-6.96	(6.77)	-0.28***	(0.10)	-0.15	(0.09)
β	-2.63	(1.92)	1.16	(1.69)	0.06	(0.05)	0.10*	(0.05)
Alcohol_days								
δ	7.16	(4.58)	-5.23	(3.95)	0.35**	(0.16)	-0.18	(0.25)
β	2.89	(1.97)	-1.62**	(0.71)	-0.09	(0.06)	-0.11	(0.08)
Alcohol_ave								
δ	1.02	(1.96)	-3.06	(4.62)	0.33***	(0.12)	0.06	(0.13)
β	-0.00	(0.94)	0.80	(0.75)	-0.01	(0.03)	-0.01	(0.02)
Alcohol_lot								
δ	2.76	(4.44)	-5.75	(6.36)	0.63**	(0.27)	0.10	(0.15)
β	-0.10	(2.59)	-2.70	(2.28)	0.02	(0.04)	-0.00	(0.04)
GPA								
δ	-1.46	(1.26)	0.14	(0.89)	0.06***	(0.02)	0.06*	(0.03)
β	-0.64	(0.72)	0.05	(0.22)	-0.01	(0.01)	-0.00	(0.01)
Binge_eat								

δ	-1.82	(2.51)	-1.31	(1.36)	0.06	(0.05)	-0.04	(0.07)
β	-1.19	(1.30)	-0.88***	(0.21)	-0.02	(0.02)	-0.04	(0.03)
Binge_shop								
δ	0.38	(1.08)	2.13*	(1.17)	0.04	(0.06)	0.02	(0.09)
β	0.18	(0.47)	0.33	(0.33)	-0.00	(0.02)	-0.04	(0.02)
Unhealthy								
δ	-0.23	(5.01)	2.10	(5.02)	-0.05	(0.18)	-0.29	(0.31)
β	0.56	(2.75)	-0.86	(1.26)	0.00	(0.04)	0.03	(0.05)
Sport_often								
δ	10.46	(7.21)	-7.10**	(3.55)	0.17	(0.14)	-0.04	(0.17)
β	8.72	(5.95)	-2.12*	(1.17)	-0.04	(0.05)	0.00	(0.05)

Notes: Standard errors in parentheses; *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The behavioural variables were obtained from the survey conducted in Week 5. The term 'Saving_rate' refers to the proportion of the monthly salary saved; 'Alcohol_days' specifies the number of days alcohol is consumed per month; 'Alcohol_ave' indicates the average number of glasses of alcohol consumed; 'Alcohol_lot' signifies whether large quantities of alcohol are consumed per month (defined as five drinks for men and four for women); 'Binge_eat' and 'Binge_shop' represent the average scores for binge eating and binge shopping, respectively, as measured by the Shorter PROMIS Questionnaire (Christo et al., 2003); 'Unhealthy' denotes whether respondents are unhealthy; 'Sport_often' indicates engagement in sports at least once per week. Ordinary Least Squares regressions are conducted for all variables except for the dummy variables 'Alcohol_lot', 'Unhealthy', and 'Sport_often', for which logit regression analysis is performed.

5. Summary and Concluding Discussions

To explore the foundational differences in time preferences between monetary and effort-related choices, we undertook a methodologically rigorous experiment. To test our hypotheses related to outcome- and sign-dependence of time preferences, this research employed a 2 × 2 experimental design that contrasts two types of outcomes—money and effort—and two domains of experience—pleasant and unpleasant. Drawing on the framework by Bosch-Domènech & Silvestre (2010), our design permitted the incentivization of all decision-making, even those involving future monetary losses. For operational efficiency, all monetary transactions were done through a mobile payment system, thereby minimizing delays and ensuring seamless transactions, akin to the methodology employed by Andreoni et al. (2018).

Our detailed analysis using descriptive measures led to several key findings. In divergence from the conclusions reached by Imai et al. (2021), our study found no evidence of present bias on average across any of the four experimental conditions. However, we did find a greater propensity for time-inconsistent behaviours in decisions involving effort. Our study also identified sign-dependence in impatience regardless of the monetary or effort-related nature of the outcome. Interestingly, the direction of this effect differed between the two. For monetary choices, we noted greater impatience in the pleasant domain, consistent with the sign effect. Conversely, in the realm of effort-based choices, a reverse sign effect was observed, characterized by a higher level of impatience in the unpleasant domain. The results imply that the sign effect may not be universally applicable across disparate types of outcomes.

Furthermore, our results indicate outcome-dependence, highlighting a higher level of impatience in unpleasant monetary choices compared with their effort-based counterparts. Effort choices also demonstrated a proclivity for balanced allocations—or a preference for smoothness—over monetary choices. At the individual level, the correlation between pleasant and unpleasant domains was notably stronger for effort choices than for monetary choices.

5.1. Absence of Present Bias Across Monetary and Effort Decisions

Our analysis revealed an absence of present bias in both monetary and effort choices, which merits further discussion. The composition of our sample of Japanese students might be a reason for this absence. Various studies have indicated that individuals from Eastern cultures, such as Japan, tend to discount future rewards less than their Western counterparts (Du et al., 2002; Ishii et al., 2017; Kim et al., 2012; Takahashi et al., 2010). This implies a greater tendency among Japanese individuals to wait for delayed rewards. However, the estimated present bias in monetary choices in Sawada & Kuroishi (2015) aligns closely with the average bias observed in a meta-analysis by Imai et al. (2021).[1] Consequently, we did not find clear evidence to suggest that present bias is different in our Japanese sample from that observed in other samples.

One might consider whether the initial amount of money or effort (2,000 units in Weeks 4 and 5) given to participants was disproportionately large compared with the values in the subsequent options. The highest value among the options was 1,510, which is nearly the maximum possible value of 2,000.

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[1] The participants in Sawada and Kuroishi's (2015) study resided in Iwanuma city, Miyagi prefecture. The city suffered damage from the 11th March 2011 Great East Japan Earthquake. Their research was carried out in May 2014. They found that the impact of the earthquake-induced disaster damage on present bias was not statistically significant.

Therefore, we do not believe that the relative differences between the initial amounts and the values in the options significantly influenced the results. This is further substantiated by Abdellaoui et al. (2018) investigating time preferences in working time, which detected a significant present bias even when the initial value was set at 4 hours (with options varying by up to ±3 hours). Moreover, our additional analysis supports the assumption that participants updated their reference points, indicating they did not consider the initial 2,000 units in their intertemporal decision-making process (refer to Appendix C for details).

5.2. Reverse Sign Effect in Effort Choices

In effort choices, participants exhibited greater impatience in the unpleasant domain compared with the pleasant domain. This outcome contradicts the sign effect. Prior literature has consistently identified the sign effect across four distinct outcomes—money, environment, health (Hardisty & Weber, 2009), and time (Abdellaoui et al., 2018).

One theoretical framework that may shed light on the sign effect is Molouki et al. (2019)'s contemplation-emotion explanation. This framework attributes the sign effect to the heightened emotional impact that individuals experience while anticipating losses, which serves as a catalyst for the effect. A plausible explanation for our observation of a reverse sign effect may lie in the distinct emotional weight carried by immediate, unpleasant tasks. These tasks are vividly conceptualized, and the future emotional burden they impose may not be as onerous for participants.

In addition, the emotional burden associated with immediate unpleasant tasks may be more potent than the more abstract notion of environmental degradation, health deterioration, or monetary loss, leading participants to delay these concrete aversive tasks. Notably, past research examining time preferences in environmental and health-related choices was not incentivized (Baker et al., 2003; Chapman, 1996; Hardisty & Weber, 2009; MacKeigan et al., 1993). Furthermore, participants may perceive immediate monetary losses as recoverable through future adjustments in consumption, a notion corroborated by Cohen et al. (2020), who emphasized the delayed nature of consumption in monetary contexts. By contrast, our study required participants to exert actual effort at certain points to complete the experiment.

Appendix

A. Pooled-Data Parameters Estimated by Maximum Likelihood Estimations (MLEs)

Table A.1 reports the MLEs for the Money and Effort treatments, using pooled data. The four parameters of the time preferences are estimated for each model. The estimated present bias β is not statistically different from 1 in all models in the two tables (as shown by the Wald test reported in the last row). The result is consistent with the findings based on our descriptive measures.

The models in the table present regression results of MLEs. Models 1 and 4 are results in the pleasant domain, Models 2 and 5 are the results in the unpleasant domain, and Models 3 and 6 include both domains. Models 3 and 6 include the 'unpleasant' dummy variable associated with unpleasant outcomes, to assess sign-dependent preferences.

We find the discount factor δ is less than 1 in the pleasant condition in the Money treatment (p =0.10, Model 1), but the parameter is not significantly different from 1 in the Effort treatment (p = 0.30, Model 4). The utility curvature α dose not significantly differ from 0 for both pleasant and unpleasant outcomes in the Money treatment (p = 0.20, Model 1; p = 0.11, Model 2, respectively). In the Effort treatment, the value is not significantly different from 0 in the unpleasant condition (p = 0.11, Model 5), but is significantly negative in the pleasant condition (p = 0.02, Model 4)

This suggests that, our subjects exhibited a linear utility function, except for pleasant outcomes in the Effort treatment where we observed a convex utility function. This result in this particular condition is not in line with previous studies, representing a unique feature of our methodology using CTB and MLE. It is critical, however, to note that this deviation occurs at the aggregate level, and we found that the majority of individuals indeed possess concave utility functions when considering individual-level data as we discussed in the main analysis.

In the Money treatment, δ is significantly larger for the unpleasant outcomes than for the pleasant ones (p = 0.002, Model 3). The results are consistent with the findings of the descriptive measures. However, no sign-dependent preference in terms of δ is found in the Effort treatment, whereas *Impatience* was significantly higher in the unpleasant domain in the descriptive measures (p = 0.87). In addition, we do not find a significant difference for β between the pleasant and unpleasant domains in both treatments Money and Effort (p = 0.58 for both treatments). This finding is again consistent with the results of our descriptive measure.

TABLE A.1. The four parameters of time preferences by MLEs.

	Money (1) Pleasant	 (2) Unpleasant	 (3) All	Effort (4) Pleasant	 (5) Unpleasant	 (6) All
δ	0.98***	1.00***	0.98***	1.16***	1.04***	1.05***
	(0.01)	(0.01)	(0.01)	(0.16)	(0.06)	(0.09)
Unpleasant			0.02***			-0.01
			(0.01)			(0.04)
β	0.99***	1.01***	1.00***	1.15***	1.09***	1.10***
	(0.01)	(0.01)	(0.01)	(0.20)	(0.11)	(0.16)
Unpleasant			-0.00			-0.03
			(0.01)			(0.05)
α	-0.10	0.05	-0.08*	-0.86**	0.21	-0.49***
	(0.08)	(0.03)	(0.05)	(0.35)	(0.13)	(0.12)
Unpleasant			0.15***			0.72***
			(0.06)			(0.15)
σ	0.02**	0.01**	0.01***	0.14*	0.17**	0.12**
	(0.01)	(0.01)	(0.00)	(0.08)	(0.07)	(0.06)
Unpleasant			0.00			0.06
			(0.01)			(0.04)
LogLikelihood	-2059.30	-2053.95	-4264.67	-5068.75	-5028.18	-10256.98
Cluster	89	89	89	76	76	76
N	3204	3204	6408	2736	2736	5472
p-value: $\delta = 1$	0.103	0.532	0.035**	0.298	0.495	0.577
p-value: $\beta = 1$	0.404	0.368	0.856	0.468	0.393	0.517

Notes: Clustered standard errors at the individual level are shown in parentheses; *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

TABLE A.2. The summary table of demographic and behavioural variables.

Variables	Money		Effort		t	p
	Mean	SD	Mean	SD		
Alcohol_days	2.56	(3.62)	2.97	(4.31)	–0.67	(0.51)
Alcohol_lot	0.88	(2.16)	1.29	(3.92)	–0.85	(0.39)
Alcohol_ave	7.47	(1.43)	7.87	(1.99)	–1.48	(0.14)
Sport_often	0.31	(0.47)	0.42	(0.50)	–1.42	(0.16)
Unhealthy	0.31	(0.47)	0.25	(0.44)	0.91	(0.36)
Binge_eat	3.30	(0.91)	3.34	(0.98)	–0.25	(0.80)
Binge_shop	3.50	(0.76)	3.52	(0.88)	–.13	(0.89)

Notes: The term ‘Alcohol_days’ specifies the number of days alcohol is consumed per month; ‘Alcohol_lot’ signifies whether large quantities of alcohol are consumed per month (defined as five drinks for men and four for women); ‘Alcohol_ave’ indicates the average number of glasses of alcohol consumed; ‘Sport_often’ indicates engagement in sports at least once per week; ‘Unhealthy’ denotes whether respondents are unhealthy; ‘Binge_eat’ and ‘Binge_shop’ represent the average scores for binge eating and binge shopping, respectively, as measured by the Shorter PROMIS Questionnaire (Christo et al., 2003).

B. Choice Consistency

Our participants demonstrated consistency to a similar degree as seen in previous studies (e.g., Cheung et al., 2022). The pass rate of the Generalized Axiom of Revealed Preference (GARP) test for the monetary decisions was extremely high in Weeks 3 and 4 (higher than 0.97 and 0.96 in the pleasant and unpleasant domains, respectively). Afriat's critical cost efficiency index (AEI), a measure of rationalizability, was more than 0.99 in all cases (the AEI of a random chooser is about 0.8). Cheung et al.'s experiment found the AEI for monetary gain decisions to be 0.98, a result similar to ours.

By contrast, the pass rate for effort decisions was relatively low, generally around 0.75. However, the AEI was above 0.96 in the two domains, suggesting that our participants' choices were generally consistent. Moreover, in the common choice set between Sets 1 and 2 (R = 0.25 in both sets), more than 94% of participants in the Money treatment and more than 82% in the Effort treatment chose the same or a neighbouring bundle. The figure ranged between 80% and 83% in the study by Cheung et al.,[2] further supporting the conclusion that our participants' choices were sufficiently consistent.[3]

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[2] Cheung et al. (2022) tested this with three outcomes (money and healthy and unhealthy foods) in the two sets.

[3] Our participants demonstrated a tendency to frequently select extreme endpoints. Specifically, in pleasant (unpleasant) scenarios, they often chose options with the maximum sooner (later) values at negative interest rates and the maximum later (sooner) values at positive rates. In fact, a significant proportion of participants consistently made such choices: 79% (83% for unpleasant) in monetary choices and 28% (22% for unpleasant) in task choices. This pattern of selection could potentially have influenced the high pass rates observed in the GARP tests.

C. Robustness Check

Analysis without the assumption of updated reference points

In Week 1 of the experiment, participants in the Effort treatment committed to transcribing 2,000 numbers during Weeks 4 and 5. The intent behind this design was to offer flexibility in task quantity, thereby creating a pleasant domain in effort choices.

In the analysis presented in the main text, we operated under the assumption that participants used this 2,000-number commitment as a reference point during their allocation decisions. Such an assumption is well-founded in existing literature (see Augenblick et al., 2015 and Abdellaoui et al., 2018). Furthermore, the seminal work by Kahneman and Tversky (1979) suggests that individuals updated their reference points in choices involving risk.

However, it is possible that participants did not update their reference points when making allocation decisions. That is, participants might have considered the entire 2,000 numbers as the baseline for all tasks. For example, in the unpleasant domain, the allocation question presented the options of adding 675 numbers in Week 4 and 250 in Week 5. However, participants could have integrated these quantities into the initial 2,000-number commitment, effectively considering tasks of 2,675 numbers in Week 4 and 2,250 in Week 5.

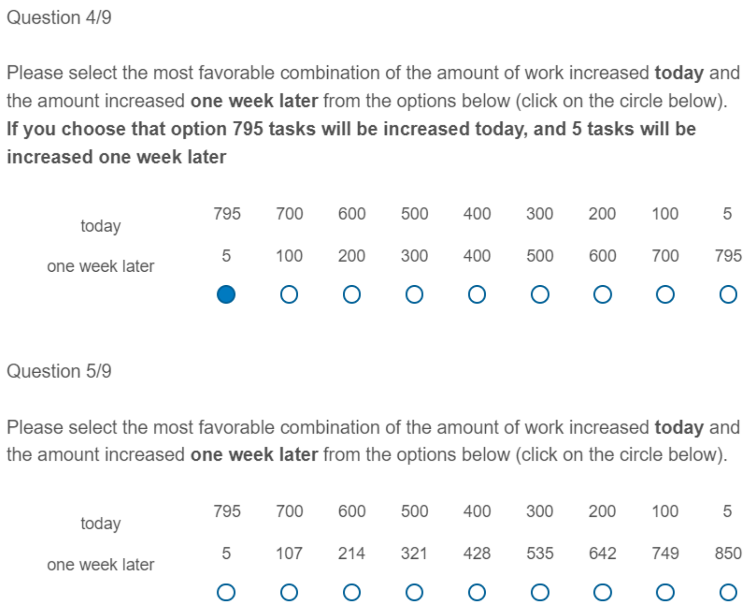
To assess the robustness of our initial assumptions, we re-estimate the time preference parameters using MLEs without assuming that reference points have been updated. We then compare the model fit of this revised approach with the original model to gauge the validity of our initial assumptions.

Table C.1 presents model-fitting indices, namely the Akaike information criterion (AIC) and Bayesian information criterion (BIC), for regression models both with and without the reference point assumption. Across all model fittings, the indices favour the model that incorporates the reference point assumption. This lends credence to our initial assumption, suggesting that participants are likely to have updated their reference points when making allocation decisions.

TABLE C.1. Regression analysis with and without the assumption of reference point.

	RP Assumption	RP Assumption	RP Assumption	No RP Assumption	No RP Assumption	No RP Assumption
α	-0.42***	0.25***	-0.42***	0.90***	1.41***	0.39***
	(0.10)	(0.06)	(0.10)	(0.16)	(0.43)	(0.11)
Unpleasant			0.67***			
			(0.15)			
β	1.04***	1.03***	1.04***	1.05***	1.03***	1.04***
	(0.07)	(0.03)	(0.07)	(0.07)	(0.03)	(0.05)
Unpleasant			-0.02			
			(0.05)			
δ	1.00***	1.00***	1.00***	1.02***	1.00***	1.01***
	(0.04)	(0.02)	(0.04)	(0.04)	(0.02)	(0.03)
Unpleasant			-0.01			
			(0.03)			
Domain	Pleasant	Unpleasant	Both	Pleasant	Unpleasant	Both
LogLikelihood	-5226.71	-5116.24	-10342.94	-5314.36	-5204.94	-10698.05
Cluster	76	76	76	76	76	76
N	2736	2736	5472	2736	2736	5472
AIC	10461.41	10240.47	20701.88	10636.71	10417.88	21404.10
BIC	10485.07	10264.13	20754.74	10660.37	10441.53	21430.53

Notes: Standard errors in parentheses; *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.



Question 4/9

Please select the most favorable combination of the amount of work increased **today** and the amount increased **one week later** from the options below (click on the circle below).
If you choose that option 795 tasks will be increased today, and 5 tasks will be increased one week later

today	795	700	600	500	400	300	200	100	5
one week later	5	100	200	300	400	500	600	700	795

Question 5/9

Please select the most favorable combination of the amount of work increased **today** and the amount increased **one week later** from the options below (click on the circle below).

today	795	700	600	500	400	300	200	100	5
one week later	5	107	214	321	428	535	642	749	850

FIGURE A.1. English translation of the screenshots of the allocation decisions in Week 4: unpleasant-effort condition with R = 0 (top) and 0.07 (bottom).

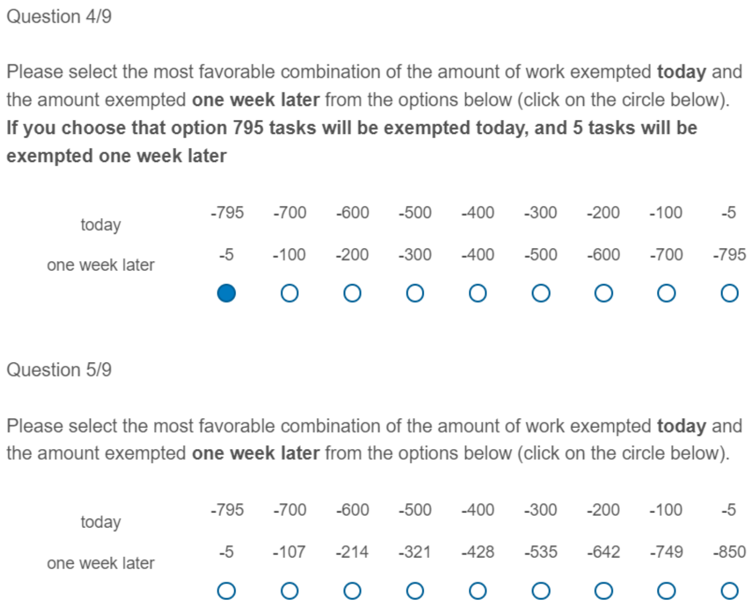


FIGURE A.2. English translation of the screenshots of the allocation decisions in Week 4: pleasant-effort condition with R = 0 (top) and 0.07 (bottom).

Question 4/9

Please select the most favorable combination of the amount you will pay **today** and the amount you will pay **one week later** from the options below (click on the circle below).
If you choose that option, you will pay 795 yen today, and you will pay 5 yen one week later

today	-795	-700	-600	-500	-400	-300	-200	-100	-5
one week later	-5	-100	-200	-300	-400	-500	-600	-700	-795
	●	○	○	○	○	○	○	○	○

Question 5/9

Please select the most favorable combination of the amount you will pay **today** and the amount you will pay **one week later** from the options below (click on the circle below).

today	-795	-700	-600	-500	-400	-300	-200	-100	-5
one week later	-5	-107	-214	-321	-428	-535	-642	-749	-850
	○	○	○	○	○	○	○	○	○

FIGURE A3. English translation of the screenshots of the allocation decisions in Week 4: unpleasant-money condition with R = 0 (top) and 0.07 (bottom).

References

Abdellaoui, Mohammed, Bleichrodt, Han, l'Haridon, Olivier, & Paraschiv, Corina. (2013). Is there one unifying concept of utility? An experimental comparison of utility under risk and utility over time. *Management Science*, *59*(9), 2153–2169. https://doi.org/10.1287/mnsc.1120.1690

Abdellaoui, Mohammed, Gutierrez, Cédric, & Kemel, Emmanuel. (2018). Temporal discounting of gains and losses of time: An experimental investigation. *Journal of Risk and Uncertainty*, *57*(1), 1–28. https://doi.org/10.1007/s11166-018-9287-1

Andreoni, James, Gravert, Christina, Kuhn, Michael A., Saccardo, Silvia, & Yang. (2018). *Arbitrage or narrow bracketing? On using money to measure intertemporal preferences* (Working Paper 25232). National Bureau of Economic Research. https://doi.org/10.3386/w25232

Andreoni, James, Kuhn, Michael A., & Sprenger, Charles. (2015). Measuring time preferences: A comparison of experimental methods. *Journal of Economic Behavior & Organization*, *116*, 451–464. https://doi.org/10.1016/j.jebo.2015.05.018

Andreoni, James, & Sprenger, Charles. (2012). Estimating time preferences from convex budgets. *American Economic Review*, *102*(7), 3333–3356. https://doi.org/10.1257/aer.102.7.3333

Angeletos, George-Marios, Laibson, David, Repetto, Andrea, Tobacman, Jeremy, & Weinberg, Stephen. (2001). The Hyperbolic Consumption Model: Calibration, Simulation, and Empirical Evaluation. *Journal of Economic Perspectives*, *15*(3), 47–68. https://doi.org/10.1257/jep.15.3.47

Ashraf, Nava, Karlan, Dean, & Yin, Wesley. (2006). Tying Odysseus to the mast: Evidence from a commitment savings product in the Philippines. *The*

Quarterly Journal of Economics, *121*(2), 635–672. https://doi.org/10.1162/qjec.2006.121.2.635

Augenblick, Ned, Niederle, Muriel, & Sprenger, Charles. (2015). Working over time: Dynamic inconsistency in real effort tasks. *The Quarterly Journal of Economics*, *130*(3), 1067–1115. https://doi.org/10.1093/qje/qjv020

Augenblick, Ned, & Rabin, Matthew. (2019). An experiment on time preference and misprediction in unpleasant tasks. *The Review of Economic Studies*, *86*(3), 941–975. https://doi.org/10.1093/restud/rdy019

Baker, Forest, Johnson, Matthew W., & Bickel, Warren K. (2003). Delay discounting in current and never-before cigarette smokers: Similarities and differences across commodity, sign, and magnitude. *Journal of Abnormal Psychology*, *112*(3), 382–392. https://doi.org/10.1037/0021-843X.112.3.382

Barlow, Pepita, Reeves, Aaron, McKee, Martin, Galea, Gauden, & Stuckler, David. (2016). Unhealthy diets, obesity and time discounting: A systematic literature review and network analysis. *Obesity Reviews*, *17*(9), 810–819. https://doi.org/10.1111/obr.12431

Bartels, Daniel M., Li, Ye, & Bharti, Soaham. (2023). How well do laboratory-derived estimates of time preference predict real-world behaviors? Comparisons to four benchmarks. *Journal of Experimental Psychology. General*, *152*(9), 2651–2665. https://doi.org/10.1037/xge0001380

Benzion, Uri, Rapoport, Amnon, & Yagil, Joseph. (1989). Discount rates inferred from decisions: An experimental study. *Management Science*, *35*(3), 270–284. https://doi.org/10.1287/mnsc.35.3.270

Bleichrodt, Han, Gao, Yu, & Rohde, Kirsten I. M. (2016). A measurement of decreasing impatience for health and money. *Journal of Risk and*

Uncertainty, *52*(3), 213–231. https://doi.org/10.1007/s11166-016-9240-0

Bosch-Domènech, Antoni, & Silvestre, Joaquim. (2010). Averting risk in the face of large losses: Bernoulli vs. Tversky and Kahneman. *Economics Letters*, *107*(2), 180–182. https://doi.org/10.1016/j.econlet.2010.01.018

Bradford, David. (2010). The association between individual time preferences and health maintenance habits. *Medical Decision Making*, *30*(1), 99–112. https://doi.org/10.1177/0272989X09342276

Bradford, David, Courtemanche, Charles, Heutel, Garth, McAlvanah, Patrick, & Ruhm, Christopher. (2017). Time preferences and consumer behavior. *Journal of Risk and Uncertainty*, *55*(2), 119–145. https://doi.org/10.1007/s11166-018-9272-8

Brewer, Judson A., & Potenza, Marc N. (2008). The neurobiology and genetics of impulse control disorders: Relationships to drug addictions. *Biochemical Pharmacology*, *75*(1), 63–75. https://doi.org/10.1016/j.bcp.2007.06.043

Carvalho, Leandro S., Meier, Stephan, & Wang, Stephanie W. (2016). Poverty and economic decision-making: Evidence from changes in financial resources at payday. *The American Economic Review*, *106*(2), 260–284. https://doi.org/10.1257/aer.20140481

Chabris, Christopher F., Laibson, David, Morris, Carrie L., Schuldt, Jonathon P., & Taubinsky, Dmitry. (2008). Individual laboratory-measured discount rates predict field behavior. *Journal of Risk and Uncertainty*, *37*(2), 237–269. https://doi.org/10.1007/s11166-008-9053-x

Chapman, Gretchen B. (1996). Temporal discounting and utility for health and money. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*(3), 771–791. https://doi.org/10.1037/0278-7393.22.3.771

Cheung, Stephen L., Tymula, Agnieszka, & Wang, Xueting. (2022). Present bias for monetary and dietary rewards. *Experimental Economics*, *25*(4), 1202–1233. https://doi.org/10.1007/s10683-022-09749-8

Christo, George, Jones, Susan L., Haylett, Samantha, Stephenson, Geoffrey M., Lefever, Robert M. H., & Lefever, Robin. (2003). The Shorter PROMIS Questionnaire: Further validation of a tool for simultaneous assessment of multiple addictive behaviours. *Addictive Behaviors*, *28*(2), 225–248. https://doi.org/10.1016/S0306-4603(01)00231-3

Cohen, Jonathan, Ericson, Keith Marzilli, Laibson, David, & White, John Myles. (2020). Measuring time preferences. *Journal of Economic Literature*, *58*(2), 299–347. https://doi.org/10.1257/jel.20191074

Courtemanche, Charles, Heutel, Garth, & McAlvanah, Patrick. (2015). Impatience, incentives and obesity. *The Economic Journal*, *125*(582), 1–31. https://doi.org/10.1111/ecoj.12124

Cubitt, Robin P., & Read, Daniel. (2007). Can intertemporal choice experiments elicit time preferences for consumption? *Experimental Economics*, *10*(4), 369–389. https://doi.org/10.1007/s10683-006-9140-2

Dohmen, Thomas, Falk, Armin, Huffman, David, & Sunde, Uwe. (2010). Are risk aversion and impatience related to cognitive ability? *American Economic Review*, *100*(3), 1238–1260. https://doi.org/10.1257/aer.100.3.1238

Du, Wanjiang, Green, Leonard, & Myerson, Joel. (2002). Cross-cultural comparisons of discounting delayed and probabilistic rewards. *The Psychological Record*, *52*(4), 479–492. https://doi.org/10.1007/BF03395199

Duckworth, Angela L., & Seligman, Martin E. P. (2005). Self-discipline outdoes IQ in predicting academic performance of adolescents. *Psychological*

Science, *16*(12), 939–944. https://doi.org/10.1111/j.1467-9280.2005.01641.x

Estle, Sara J., Green, Leonard, Myerson, Joel, & Holt, Daniel D. (2007). Discounting of monetary and directly consumable rewards. *Psychological Science*, *18*(1), 58–63. https://doi.org/10.1111/j.1467-9280.2007.01849.x

Falk, Armin, Becker, Anke, Dohmen, Thomas, Enke, Benjamin, Huffman, David, & Sunde, Uwe. (2018). Global Evidence on Economic Preferences*. *The Quarterly Journal of Economics*, *133*(4), 1645–1692. https://doi.org/10.1093/qje/qjy013

Frederick, Shane, Loewenstein, George, & O'Donoghue, Ted. (2002). Time discounting and time preference: A critical review. *Journal of Economic Literature*, *40*(2), 351–401. https://doi.org/10.1257/002205102320161311

Ganiats, Theodore G., Carson, Richard T., Hamm, Robert M., Cantor, Scott B., Sumner, Walton, Spann, Stephen J., Hagen, Michael D., & Miller, Christopher. (2000). Population-based time preferences for future health outcomes. *Medical Decision Making*, *20*(3), 263–270. https://doi.org/10.1177/0272989X0002000302

Hardisty, David J., & Weber, Elke U. (2009). Discounting future green: Money versus the environment. *Journal of Experimental Psychology: General*, *138*(3), 329–340. https://doi.org/10.1037/a0016433

Harris, Christine R. (2012). Feelings of dread and intertemporal choice. *Journal of Behavioral Decision Making*, *25*(1), 13–28. https://doi.org/10.1002/bdm.709

Ida, Takanori. (2014). A quasi-hyperbolic discounting approach to smoking behavior. *Health Economics Review*, *4*(1), 5. https://doi.org/10.1186/s13561-014-0005-7

Imai, Taisuke, Rutter, Tom A., & Camerer, Colin F. (2021). Meta-analysis of present-bias estimation using convex time budgets. *Economic Journal*, *636*, Article 636. https://doi.org/10.1093/ej/ueaa115

Ishii, Keiko, Eisen, Charis, & Hitokoto, Hidefumi. (2017). The effects of social status and culture on delay discounting. *Japanese Psychological Research*, *59*(3), 230–237. https://doi.org/10.1111/jpr.12154

Kahneman, Daniel, & Tversky, Amos. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, *47*(2), 263–291. https://doi.org/10.2307/1914185

Kim, Bokyung, Sung, Young Shin, & McClure, Samuel M. (2012). The neural basis of cultural differences in delay discounting. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *367*(1589), 650–656. https://doi.org/10.1098/rstb.2011.0292

Laibson, David. (1997). Golden eggs and hyperbolic discounting. *The Quarterly Journal of Economics*, *112*(2), 443–478. https://doi.org/10.1162/003355397555253

Loewenstein, George. (1987). Anticipation and the valuation of delayed consumption. *The Economic Journal*, *97*(387), 666–684. https://doi.org/10.2307/2232929

MacKeigan, Linda D., Larson, Lon N., Draugalis, JoLaine R., Bootman, J. Lyle, & Burns, Lawton R. (1993). Time preference for health gains versus health losses. *PharmacoEconomics*, *3*(5), 374–386. https://doi.org/10.2165/00019053-199303050-00005

Meier, Stephan, & Sprenger, Charles. (2010). Present-biased preferences and credit card borrowing. *American Economic Journal: Applied Economics*, *2*(1), 193–210. https://doi.org/10.1257/app.2.1.193

Meissner, Thomas, & Pfeiffer, Philipp. (2022). Measuring preferences over the temporal resolution of consumption uncertainty. *Journal of Economic Theory*, *200*, 105379. https://doi.org/10.1016/j.jet.2021.105379

Molouki, Sarah, Hardisty, David J., & Caruso, Eugene M. (2019). The sign effect in past and future discounting. *Psychological Science*, *30*(12), 1674–1695. https://doi.org/10.1177/0956797619876982

Myerson, Joel, Baumann, Ana A., & Green, Leonard. (2017). Individual differences in delay discounting: Differences are quantitative with gains, but qualitative with losses. *Journal of Behavioral Decision Making*, *30*(2), 359–372. https://doi.org/10.1002/bdm.1947

O'Donoghue, Ted, & Rabin, Matthew. (1999). Doing it now or later. *American Economic Review*, *89*(1), 103–124. https://doi.org/10.1257/aer.89.1.103

O'Donoghue, Ted, & Rabin, Matthew. (2001). Choice and procrastination. *The Quarterly Journal of Economics*, *116*(1), 121–160. https://doi.org/10.1162/003355301556365

O'Donoghue, Ted, & Rabin, Matthew. (2015). Present bias: Lessons learned and to be learned. *American Economic Review*, *105*(5), 273–279. https://doi.org/10.1257/aer.p20151085

Odum, Amy L., Baumann, Ana A. L., & Rimington, Delores D. (2006). Discounting of delayed hypothetical money and food: Effects of amount. *Behavioural Processes*, *73*(3), 278–284. https://doi.org/10.1016/j.beproc.2006.06.008

Odum, Amy L., Madden, Gregory J., & Bickel, Warren K. (2002). Discounting of delayed health gains and losses by current, never- and ex-smokers of cigarettes. *Nicotine & Tobacco Research*, *4*(3), 295–303. https://doi.org/10.1080/14622200210141257

Reed, Derek D., & Martens, Brian K. (2011). Temporal discounting predicts student responsiveness to exchange delays in a classroom token system. *Journal of Applied Behavior Analysis*, *44*(1), 1–18. https://doi.org/10.1901/jaba.2011.44-1

Reuben, Adrian, Koch, David G., & Lee, William M. (2010). Drug-induced acute liver failure: Results of a U.S. multicenter, prospective study. *Hepatology*, *52*(6), 2065–2076. https://doi.org/10.1002/hep.23937

Sawada, Yasuyuki, & Kuroishi, Yusuke. (2015). How to Strengthen Social Capital in Disaster Affected Communities? The Case of the Great East Japan Earthquake. In *Disaster Risks, Social Preferences, and Policy Effects: Field Experiments in Selected ASEAN and East Asian Countries* (pp. 163–199). ERIA.

Scholten, Marc, & Read, Daniel. (2010). The psychology of intertemporal tradeoffs. *Psychological Review*, *117*(3), 925–944. https://doi.org/10.1037/a0019619

Shiba, Shotaro, & Shimizu, Kazumi. (2020). Does time inconsistency differ between gain and loss? An intra-personal comparison using a non-parametric elicitation method. *Theory and Decision*, *88*(3), 431–452. https://doi.org/10.1007/s11238-019-09728-1

Strotz, R. H. (1955). Myopia and inconsistency in dynamic utility maximization. *The Review of Economic Studies*, *23*(3), 165–180. https://doi.org/10.2307/2295722

Sutter, Matthias, Kocher, Martin G., Glätzle-Rützler, Daniela, & Trautmann, Stefan T. (2013). Impatience and uncertainty: Experimental decisions predict adolescents' field behavior. *American Economic Review*, *103*(1), 510–531. https://doi.org/10.1257/aer.103.1.510

Takahashi, Taiki, Hadzibeganovic, Tarik, Cannas, Sergio A., Makino, Takaki, Fukui, Hiroki, & Kitayama, Shinobu. (2010). Cultural Neuroeconomics of Intertemporal Choice. *Journal of Behavioral Economics and Finance*, *3*, 133–135. https://doi.org/10.11167/jbef.3.133

Tanaka, Tomomi, Camerer, Colin F., & Nguyen, Quang. (2010). Risk and time preferences: Linking experimental and household survey data from Vietnam. *American Economic Review*, *100*(1), 557–571. https://doi.org/10.1257/aer.100.1.557

Thaler, Richard. (1981). Some empirical evidence on dynamic inconsistency. *Economics Letters*, *8*(3), 201–207. https://doi.org/10.1016/0165-1765(81)90067-7

Tsukayama, Eli, & Duckworth, Angela Lee. (2010). Domain-specific temporal discounting and temptation. *Judgment and Decision Making*, *5*(2), 72–82. https://doi.org/10.1017/S1930297500000930

Van Der Pol, Marjon M., & Cairns, John A. (2000). Negative and zero time preference for health. *Health Economics*, *9*(2), 171–175. https://doi.org/10.1002/(SICI)1099-1050(200003)9:2<171::AID-HEC492>3.0.CO;2-Z

Vuchinich, Rudy E., & Simpson, Cathy A. (1998). Hyperbolic temporal discounting in social drinkers and problem drinkers. *Experimental and Clinical Psychopharmacology*, *6*(3), 292–305. https://doi.org/10.1037/1064-1297.6.3.292

Weber, Elke U., Shafir, Sharoni, & Blais, Ann-Renée. (2004). Predicting risk sensitivity in humans and lower animals: Risk as variance or coefficient of variation. *Psychological Review*, *111*(2), 430–445. https://doi.org/10.1037/0033-295X.111.2.430

Yamamoto, Shohei, & Navarro-Martinez, Daniel. (2022). The endowment effect in the future: How time shapes buying and selling prices. *Judgment and Decision Making*, *17*(5), 988–1014. https://doi.org/10.1017/S1930297500009293

Yamamoto, Shohei, Shiba, Shotaro, & Hanaki, Nobuyuki. (2020). Time preferences in the gain and loss domains: An incentivized experiment. *Working Papers*, Article 2012. https://ideas.repec.org//p/wap/wpaper/2012.html

Yates, J. Frank, & Watts, Royce A. (1975). Preferences for deferred losses. *Organizational Behavior and Human Performance*, *13*(2), 294–306. https://doi.org/10.1016/0030-5073(75)90051-3

Yoon, Haewon, & Chapman, Gretchen B. (2016). A closer look at the yardstick: A new discount rate measure with precision and range. *Journal of Behavioral Decision Making*, *29*(5), 470–480. https://doi.org/10.1002/bdm.1890