Cognitive mechanisms of the defer-speedup and date-delay framing effects in intertemporal choice

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Abstract

Intertemporal choices, such as when choosing between rewards that are smaller but delivered sooner and those that are larger but delivered later, are influenced by the way in which time is framed. For instance, framing a reward in terms of deferring its arrival shifts preferences to the smaller-sooner option, whereas framing it in terms of speeding up its arrival shifts preferences to the larger-later option (defer-speedup effect). Similarly, framing the time of reward delivery as a calendar date shifts preferences to the larger-later option (date-delay effect). A mechanistic understanding of these framing effects is currently lacking, but could help the development of better decison-making models and more effective behavioral interventions. Here, we investigate the cognitive mechanisms underlying the defer-speedup and date-delay effecs in intertemporal choice, using computational modeling of choices and response times. For each framing effect, we test three hypotheses: (1) framing alters how outcomes are valued, (2) framing alters how times are perceived, and (3) framing alters both how outcomes are valued and how times are perceived. These hypotheses are implemented as parameterizations of the value and time functions of the computational model, respectively. In this preregistration, we report how we determined our sample size, all data exclusion criteria, all manipulations, and all measures in the study. Also, we describe the task, procedure, and modeling approach. [Data management plan: https://doi.org/10.6084/m9.figshare.4720978; Intertemporal choice task: https://github.com/bramzandbelt/itch_time_framing_task; Computational model: https://github.com/bramzandbelt/itchmodel]

1 Introduction

Many decisions, from the most mundane (e.g. whether or not to eat a candy bar when you get the munchies) to those changing our lives (e.g. whether to continue or quit smoking cigarettes) and societies (e.g. whether to relief or impose laws and tax regulations to advance the population's health), involve an intertemporal choice: a choice between options whose consequences occur at different points in time. In the laboratory, intertemporal choice is typically studied by having people choose between hypothetical rewards that are smaller but delivered sooner (e.g. €21.76 today) and those that are larger but delivered later (e.g. €43.52 in 32 days). A phenomenon that has fascinated scholars from diverse disciplines for decades is that people, despite different intentions, often prefer smaller-but-sooner rewards (e.g. satisfying your sweet tooth by eating a candybar, smoking cigarettes to cope with stress, and cutting laws and tax regulations for short-term electoral success) over larger-but-later ones (e.g. being in good shape because of avoiding high-caloric snacks, boosting life expectancy because of quitting smoking, and having a healthier population and lower healthcare costs because of laws and tax regulations). Therefore, a key question is: how can we help people become better at resisting temptations and align their behavior with their long-term intentions?

One promising strategy for improving people's intertemporal decision-making is framing. An intervention from behavioral economics, framing targets the way in which choices are formulated, exploiting people's cognitive biases to influence decision making (Tversky and Kahneman [1981]; Loewenstein [1988]; Lempert and Phelps [2016]). For instance, people tend to shift preferences to the larger-but-later option when the choice frame draws attention to opportunity costs (Magen et al. [2008]; Radu et al. [2011]), uses investment language (Read et al. [2013]), or induces episodic future thinking (Peters and Büchel [2010]; Bromberg et al. [2015]). Framing-based interventions are promising because they shift people's preferences with little cognitive effort, are simple to implement, and are low-cost. Yet, how framing influences intertemporal choice remains largely unknown. A mechanistic understanding of framing effects is important because it has the potential to help scientists to develop better decision-making models, policy makers to design more effective behavioral interventions, and people to make smarter choices.

Here, we study one particular type of framing in intertemporal choice: how time or delay is formulated, henceforth referred to as time framing. Time framing has been shown to influence intertemporal choice in several ways. One phenomenon is the defer-speedup effect [Loewenstein, 1988] [1]: when time of reward delivery is framed as a deferral (Figure 1, upper-left panel), people tend to choose the larger-but-later option less often and demand more money than when time of reward delivery is framed as a neutral delay (Figure 1, upper-right panel); when time of reward delivery is framed as a speedup (Figure 1, lower-left panel), people tend to choose the larger-but-later option more often and offer less money than when time of reward delivery is framed as a neutral delay. Another phenomenon is the date-delay effect [Read et al., 2005]: when the time of reward delivery is framed as a calendar date (Figure 1, lower-right panel), people tend to choose the larger-but-later option more often and are willing to wait longer for it than when the time of reward delivery is described as a delay (Figure 1, upper-right panel). Several studies have now replicated the defer-speedup effect [Benzion et al., 1989, Shelley, 1993, Malkoc and Zauberman, 2006, Weber et al., 2007, McAlvanah, 2010, Spears et al., 2010, Appelt et al., 2011, Scholten and Read, 2013] and date-delay effect [LeBoeuf, 2006, Scherbaum et al., 2012, Dshemuchadse et al., 2013, DeHart and Odum, 2015]. Yet, the cognitive mechanism explaining time framing effects in intertemporal choice remains unclear.

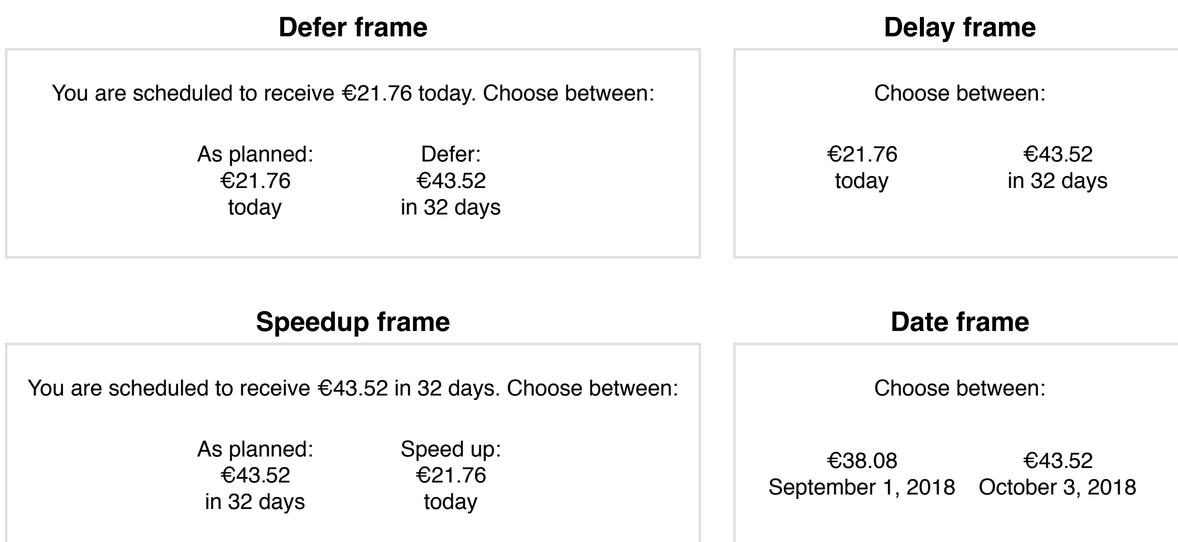

Figure 1: Time framing in intertemporal choice. Time of reward framed as a deferral (upper left) or speedup (lower left); and in terms of a delay (upper right) or a calendar date (lower right). The neutral framing in the defer-speedup effect is identical to the delay frame (upper right).

One view is that time framing effects in intertemporal choice are due to differences in how outcomes are

[1] Also known as delay/speedup effect.

valued. The defer-speedup effect, according to this view, reflects that people adapt psychologically to the expected outcome [Loewenstein, 1988, Loewenstein and Prelec, 1992, Scholten and Read, 2013], similar to reference-dependence in prospect theory [Kahneman and Tversky, 1979]. Not obtaining a positive outcome when expected (as occurs in deferring and speeding up) is a worse-than-expected state, to which people are hypersensitive [Scholten and Read, 2013]. This decreases the outcome advantage of deferring a receipt and increases the outcome disadvantage of speeding it up. The date-delay effect, according to this view, is due to people preferring the precision of a date to the vagueness of a delay, assigning greater value to the same option [Read et al., 2005]. Empirical support for this idea comes from a study showing that value differences between options had greater impact on the intertemporal choice process when choices were framed in a date format as compared to a delay format [Dshemuchadse et al., 2013].

An alternative view is that time framing effects in intertemporal choice are due to differences in how time is perceived. The defer-speedup effect, according to this view, reflects that people adapt psychologically to the expected timing of the outcome, rather than to the expected outcome itself [Scholten and Read, 2013]. Deferring a reward is treated as a loss of time in obtaining it and hypersensitivity to time lost drives up the price people demand; speeding up a reward is treated as a gain of time in obtaining it and hyposensitivity to time gained drives down the price they offer [2]. Computational modeling of indifference data from matching and preference data from choice suggests that the defer-speedup effect is better explained by a model in which framing influences how time is perceived than a model in which framing influences how outcomes are valued [Scholten and Read, 2013]. The date-delay effect, according to this view, reflects that time intervals defined by calendar dates seem shorter (time horizon is more contracted) than intervals framed in terms of a delay [Read et al., 2005]. Indeed, when people were asked to judge the subjective length of a future time interval on a visual analog scale, reported lengths were shorter for time intervals expressed in terms of calendar dates than those expressed as delays [Zauberman et al., 2009].

The goal of this study is to contrast these views in order to determine determine whether time framing in intertemporal choice influences outcome valuation (H_{ov}), time perception (H_{tp}), or both (H_{ov+tp}). To test these three hypotheses, we will collect performance data (choices and response times) in two independent samples: one sample performing an intertemporal choice task with defer, speedup, and neutral frames (defer-speedup task)[3], and another sample performing an intertemporal choice task with date and delay frames (date-delay task). We will analyze these data using a computational model that builds on previous frameworks of intertemporal choice [Busemeyer and Townsend, 1993, Scholten and Read, 2010, 2013, Dai and Busemeyer, 2014]. This model explains intertemporal choice as a three-step process (Figure 2A). In step 1, money is transformed into utility Figure 2B, upper panel), time is transformed into perceived time (Figure 2B, middle panel) and attribute-wise differences between options are calculated. In step 2, the difference in utility is compared against the difference in perceived time, with different attentional weights. In step 3, the resulting preference is accumulated over time to a threshold that triggers an explicit choice and a response time (Figure 2B, lower panel).

The three hypotheses result in different predictions, which are implemented as different parameterizations of the computational model (Figure 2C). First, if time framing in intertemporal choice influences how outcome is valued (H_{ov}), then we should find that fitting the performance data requires varying the value function between frames (Figure 2C, top panels). Second, if time framing in intertemporal choice influences how time is perceived (H_{tp}), then we should find that fitting the performance data requires varying the time function between frames (Figure 2C, bottom panels). Third, if time framing in intertemporal choice influences both how outcome is valued and time is perceived (H_{ov+tp}),then we should find that that fitting the performance data requires varying both the value and time functions between frames (Figure 2C, top and bottom panels). Model comparison, based on the Bayesian Information Criterion, will select the model that fits the data best.

To confirm that this computational modeling analysis provides a fair test of our research question, we will

[2]Note that there is no time gained or lost in and of itself; instead, time is gained or lost in obtaining a reward [for details, see Scholten and Read, 2013].

[3]Scholten & Read [2013] tested whether the defer-speedup effect could be explained in terms of outcome valuation and time weighting. We go beyond this study by testing these and additional hypotheses, using models that account not only for choice but also for response time, more data points per participant, and by manipulating framing within participants.

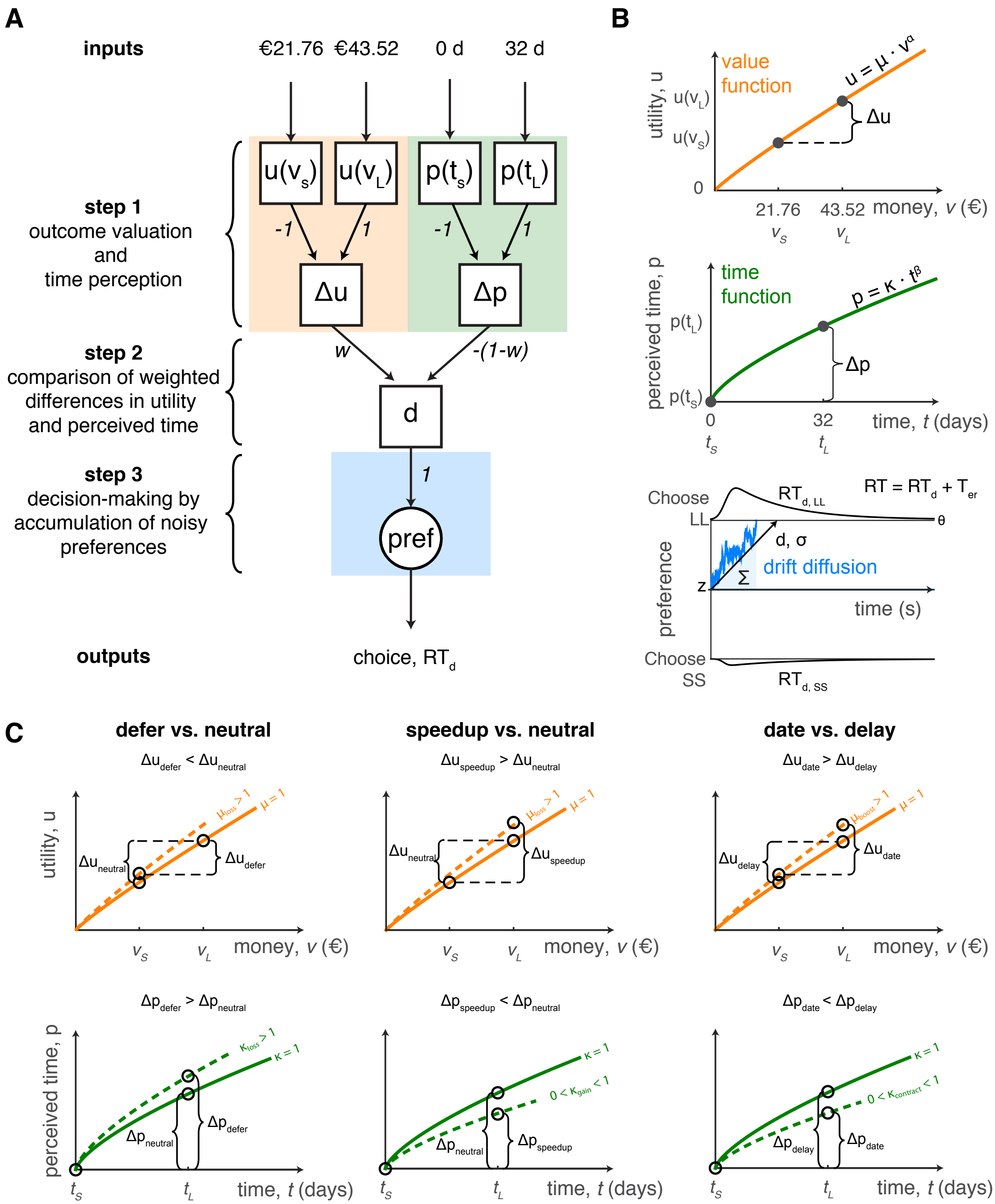

Figure 2: Computational model of intertemporal choice. (A) Model architecture. Intertemporal choice is modeled as a 3-step process: (1) transformation of money into utility (orange panel) and time into perceived time (green panel) and calculation of attribute-wise differences; (2) comparison of differences in utility and perceived time by different attentional weights, resulting in an overall preference d (when d is negative, the smaller-but-sooner option is preferred; when d is positive, the larger-but-later option option is preferred); (3) decision-making through a preference accumulation process. (B) Model dynamics. Transformation of money into utility (upper panel) and time into perceived time (middle panel) are governed by power functions. Preference accumulation is implemented by a diffusion-to-bound process. (C) Model parameterizations. For details, see Model parameterizations.

perform two sets of control analyses. First, to assess whether participants paid attention, we will analyze accuracy on catch trials and instruction manipulation check trials as well as response times on standard intertemporal choice trials. If participants paid attention to the stimuli, then we should find that accuracy is high and anticipatory responses (i.e. those with fast response times) and omitted responses are rare. Second, to assess whether we replicate the defer-speedup effect and date-delay effects, we will analyze how frames affect the area under the curve of successive delay-indifference point pairings, using Bayesian hypothesis testing. If time framing influences intertemporal choice just like previous studies did ($H_{rep,1}$), then we should find that the area under the curve of successive delay-indifference point pairings is greater for neutral than for defer frames and greater for speedup than for neutral frames in the defer-speedup task (Figure 3, upper-left), and that it is greater for date than for delay frames in the date-delay task (Figure 3, upper-right). In contrast, if time framing does not influence intertemporal choice ($H_{rep,0}$), then we should find that the area under the curve does not differ between frames (Figure 3, lower panels).

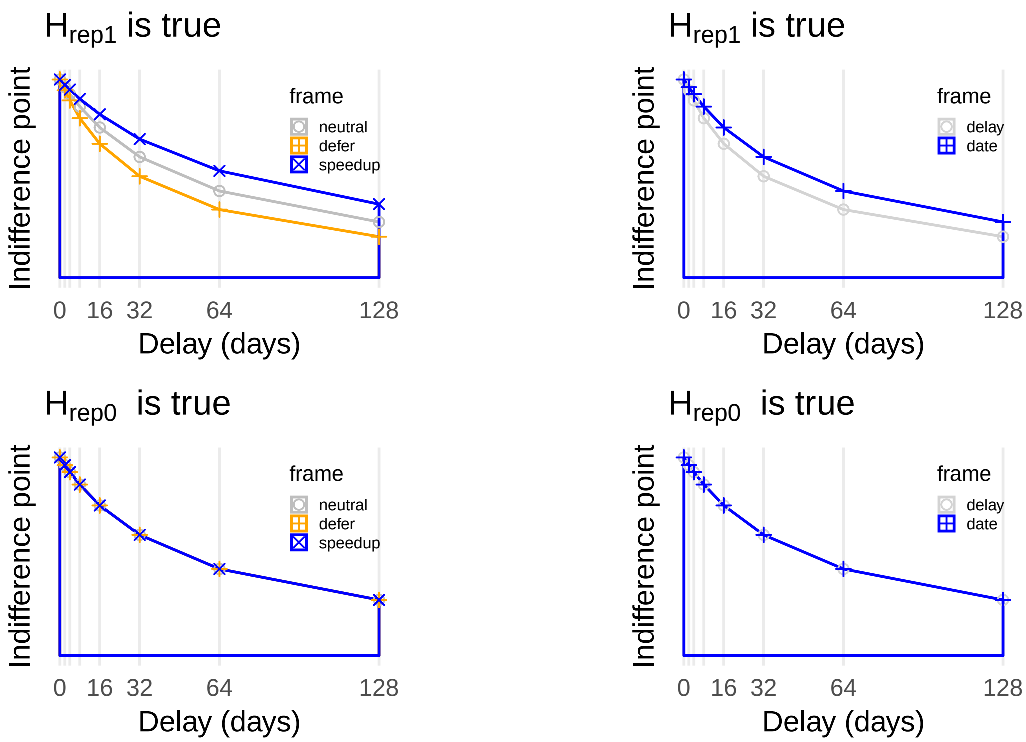

Figure 3: Predicted framing effects in the defer-speedup task (left) and date-delay task (right) on area under the curve of successive delay-indifference point pairings under $H_{rep,1}$ (top) and $H_{rep,0}$ (bottom)

2 Methods

2.1 Open science and transparent reporting

The hypotheses and analysis plan are preregistered on Open Science Framework at https://osf.io/rzqh9/. A data management plan is available at https://doi.org/10.6084/m9.figshare.4720978. The task is available at https://github.com/bramzandbelt/itch_time_framing_task. The code for the cognitive model is available at https://github.com/bramzandbelt/itchmodel. Before publication of the final manuscript, all code and data needed to reproduce the analyses and results will be made available on Zenodo to guarantee long-term access to the orginal code.

2.2 Participants

To determine the number of trials we need to collect, we ran model and parameter recovery analyses. These analyses showed that we can discriminate models with high accuracy when we collect 276 trials (defer-speedup task) or 184 trials (date-delay task) per participant. To estimate the number of participants that are needed to test our hypotheses, we performed a Bayes Factor Design Analysis. This analysis showed that if time framing influences intertemporal choice, then we should be able to find evidence for these effects by collecting a maximum number of 80 participants per intertemporal choice task.

Data collection will start after October 2, 2018. Data collection will terminate when the targeted sample size has been reached or on December 31, 2018, whichever happens first. Participants will be recruited through an online database for subjects interested in participating in research at the Donders Institute and Behavioral Science Institute at Radboud University (Sona Systems Ltd., Tallinn, Estonia).

The exclusion criteria for participation in this study are:
- age $<$ 18 years;
- a history of or current neurological or psychiatric treatment;
- pregnancy.

After study enrollment, participants will be excluded and replaced if performance meets any of the following criteria (see Procedure and Appendix B - Instructions for participants (English)):
- noncompliance with task instructions;
- accuracy $<$ 75% on catch trials and instruction manipulation check trials;
- fast response time ($<$ 1500 ms, [Dai and Busemeyer, 2014]) on $>$ 25% of standard intertemporal choice trials;
- no response on $>$ 25% of standard intertemporal choice trials;

Finally, individuals will be excluded on an analysis-by-analysis basis if their data point lies more than 2.5 standard deviation from the sample mean (see Effect of framing on area under the curve of successive delay-indifference point pairings).

The study procedures are in accordance with the latest version Declaration of Helsinki and have been approved by the local Institutional Review Board. The study's data management plan has been approved by the Radboud University data protection officer.

2.3 Apparatus and stimuli

The experiment will be run in PsychoPy [Peirce, 2007, 2008, release 1.83.04] running under Windows 7 on a Dell Precision Tower 5810 computer with a Xeon E5-1620 3.6 GHz quad core processor and 32 GB of RAM. Visual stimuli will be projected on a screen positioned approximately 70 cm from the subject.

Stimuli will be presented in white on a grey background. The trial instruction (e.g. "Choose between") is presented at the horizontal midline, 3 degrees above the vertical midline. The smaller-but-sooner and larger-but-later options are presented 6 degrees left and right from the horizontal midline, at the vertical midline. A rectangle, subtending 10 degrees along its horizontal axis and 4 degrees along its vertical axis, surrounds the chosen option. A warning message, if any, is presented at the horizontal midline, 4.5 degrees above the vertical midline. All text stimuli are presented in Helvetica and subtend 1 degree along their vertical axis.

2.4 Procedure

In the defer-speedup task, each trial begins with the presentation of the trial instruction stimulus. After 1000 ms, the smaller-but-sooner and larger-but-later options are presented. As soon as the participant responds by pressing a button, the chosen option is surrounded by a yellow rectangular frame and a warning message, if any, is presented. After 1000 ms, all stimuli are removed, and after a further 200 ms the next trial starts.

In the date-delay task, the sequence and timing of events is the same, except that trial instruction and choice options are presented simultaneously from trial onset.

Participants are instructed to indicate on each trial whether they prefer the smaller-but-sooner or larger-but-later option by pressing keys on a keyboard, corresponding to the side of the prefered option on the screen. They will be asked to consider each scenario carefully, to respond to the hypothetical choices as if they are real, and to make responses as quick as possible. To ensure that participants pay attention to the choice stimuli, the experiment also includes catch trials in which participants should logically prefer the smaller-but-sooner option (options have identical amounts, but differ in delay) or larger-but-later option (small amount equals €0.00). To ensure that participants pay attention to the trial instruction in the defer-speedup task, the experiment further includes instruction manipulation check trials [cf. Oppenheimer et al., 2009]. In these trials, the last part of the trial instruction reads "PRESS RETURN." rather than "Choose between:".

The experiment begins with written and verbal instructions (see Appendix B - Instructions for participants (English)). After instructions, subjects will be given 10 practice trials to familiarize the participant with the task. Next, participants will perform an adjusting-amount intertemporal choice task (i.e. a calibration task) to determine the indifference points [Frye et al., 2016] to be used in the main experiment. The rationale for this is that framing effects are largest around the indifference points. Participants perform 7 self-paced titration trials per delay. On the first trial, the amount of the smaller-but-sooner option equals half of the amount of the larger-but-later option. The participant's choice determines the amount of the smaller-but-sooner option on the next trial: if the participant chooses the smaller-but-sooner option, it will be decreased; if the participant chooses the larger-but-later option, it will be increased. The adjustment equals the amount of the larger-but-later option multiplied by 2^{-n}, where n is the trial number of the upcoming trial. The amount of the smaller-but-sooner option on the 7th trial is used as the indifference point in the experiment. Choices are presented in delay framing and are otherwise identical to choices used in the experiment. In addition to the 7 titration trials per delay, the adjusting-amount intertemporal choice task includes two catch trials and, in case of the defer-speedup task, one instruction manipulation check trial. A warning message is presented when participants choose the irrational option on catch trials, disobey the instruction to press the return key on instruction manipulation check trials, or when they respond faster than 1500 ms or not within 10000 ms.

The calibration task will be repeated if any of the following conditions are met:
- low accuracy (< 75% correct) on catch trials and instruction manipulation check trials, indicating that participants paid insufficient attention to the instructions and options;
- fast responses (< 1500 ms) on more than 25% of titration trials, suggesting that participants paid insufficient attention to the options;
- indifference points that do not monotonically decrease with delay [Johnson and Bickel, 2008], as indicated by the indifference point corresponding to the longest delay of 128 days was greater than €42.16 (97% of the maximum amount) or at least one indifference point was greater than the preceding indifference point by a value of more than €8.70 (20% of the maximum amount).

If these conditions are not met after three attempts, we will terminate the experiment and exclude the participant.

In the calibration task and the main experiment (i.e. defer-speedup and date-delay task), we fix the amount of the larger-but-later option (v_l: €43.52 [4]) and the delay duration to the smaller-but-sooner option (t_s: 0 days). In the main experiment, we will orthogonally vary the money amount of the smaller-but-sooner option (v_s, $log_2(t_l) \times 0.34$ below the indifference point, at the indifference point, $log_2(t_l) \times 0.34$ above the indifference point), the delay duration to the larger-but-later option (t_l, 2, 4, 8, 16, 32, 64, 128 days), and the frame in which the choice is presented ($frame$: neutral, deferral, speedup (defer-speedup task); $frame$: delay, date (date-delay task)). Each combination of v_s, t_l, and $frame$ will be shown four times, with v_s and

[4] This amount is motivated as follows: First, an influential study on intertemporal choice [Hare et al., 2014] used an indifference procedure in which the maximum money amount offered for delays of 50 up to 200 days (i.e. the range of our longest delays, see below) was USD 54, which roughly amounts to €44. Second, we will use an 7-step staircase procedure in which the money amount in which the adjustment for trial n is equal to the maximum amount multiplied by 2^{-n}. Consequently, the final adjustment is equal to $v_l 2^{-7} = 44 \cdot 2^{-7} = 0.34375$. Rounding this to €0.34, v_l becomes $v_l = 0.34 \cdot 2^7 = 43.52$.

t_l varying randomly between trials and $frame$ randomly between blocks. On each trial, we measure choice and response time.

The defer-speedup task consists of 252 (91%) regular trials, 16 (6%) catch trials, and 8 (3%) instruction manipulation check trials, divided between three blocks of 92 trials. The date-delay task consists of 168 (91%) regular trials and 16 (9%) catch trials, divided between two blocks of 92 trials. The order of blocks will be randomized and balanced across participants.

2.5 Computational modeling

2.5.1 Model architecture

To identify the cognitive mechanisms that are influenced by time framing, we will fit the behavioral choices and response times with a cognitive model (Figure 2), implemented in R (code available at http://www.github.com/bramzandbelt/itchmodel). This model is based on two tradeoff models of intertemporal choice, one that is able to account for the defer-speedup effect on intertemporal choices [Scholten and Read, 2013] and another that has been shown to explain choice probabilities and full response time distributions in intertemporal choice [Dai and Busemeyer, 2014]. It explains intertemporal choice as a three-step process (Figure 2A).

In step 1, money v is transformed into utility u (Figure 2B, upper panel), time t is transformed into perceived time p (Figure 2B, middle panel), and attribute-wise differences between options are calculated. The transformations are goverened by power functions:

$$u(v) = \mu \cdot v^{\alpha} \tag{1}$$

, and

$$p(t) = \kappa \cdot t^{\beta} \tag{2}$$

, where μ and κ are scaling parameters and α and β are sensitivity parameters. The attribute-wise differences are calculated simply as:

$$\Delta u = u(v_l) - u(v_s) = \mu \cdot v_l^{\alpha} - \mu \cdot v_s^{\alpha}, \tag{3}$$

, and

$$\Delta p = p(t_l) - p(t_s) = \kappa \cdot tl^{\beta} - \kappa \cdot ts^{\beta}, \tag{4}$$

In step 2, the difference in utility is compared against the difference in perceived time, with different attentional weights, respectively w and $1 - w$, resulting in d:

$$d = w \cdot \Delta u - (1 - w) \cdot \Delta p, \tag{5}$$

, which represents the overall advantage of the larger-but-later option over the smaller-but-sooner option. Thus, when d is positive, a decision-maker tends to prefer the larger-but-later option; when d is negative, they tend to prefer the smaller-but-sooner option.

In step 3, preference for and against each option is accumulated over time until the preference strength for one of the option reaches a threshold (Figure 2B, lower panel). When this happens, a decision is made to choose the option whose accumulated preference strength reached the threshold. The time that accumulation takes plus the time for non-decisional components, such as stimulus encoding and response execution, determines the actual response time. This accumulation process is governed by five parameters: (1) the mean rate of preference of the larger-but-later option over the smaller-but-sooner option, d; (2) the diffusion constant, σ; (3) the threshold on preference strength, θ; (4) the initial preference level before the accumulation process starts, z; and (5) the time needed for nondecisional components such as stimulus encoding and response execution, T_{ER}.

Equations for the binary choice probability of choosing the larger-but-later option are given by Dai & Busemeyer [Dai and Busemeyer, 2014],

$$P(LL|d,\sigma,\theta,z) = \frac{1 - e^{\frac{-2d(\theta+z)}{\sigma^2}}}{1 - e^{\frac{-4d\theta}{\sigma^2}}}, \tag{6}$$

,and those for response times distributions can be found in work by Ratcliff [Ratcliff, 1978, Tuerlinckx et al., 2001] and Busemeyer and Diederich [Busemeyer and Diederich, 2010].

2.5.2 Model parameterizations

Our hypotheses are instantiated as model parameterizations of the value and time functions.

2.5.2.1 Defer-speedup effect explained by outcome valuation (H_{ov})

The defer-speedup effect may arise from people adapting psychologically to the expected outcome [Loewenstein, 1988, Loewenstein and Prelec, 1992, Scholten and Read, 2013]. For the model parameterization, we follow Scholten & Read [2013]. Not obtaining a positive outcome when expected, as occurs in deferring and speeding up a reward, is a worse-than-expected state, to which people are hypersensitive. When deferring a reward, the impact of giving up the immediate reward is $-\mu_{loss}u(v_s)$, where $\mu_{loss} > 1$ is hypersensitivity to worse-than-expected states, and the impact of the compensation by the delayed reward is $u(v_l)$ (Figure 2C, upper-left panel). When speeding up a reward, the impact of giving up the delayed reward is $-\mu_{loss}u(v_l)$, where $\mu_{loss} > 1$ is hypersensitivity to worse-than-expected states, and the impact of the compensation by the delayed reward is $u(v_s)$ (Figure 2C, upper-middle panel). Hypersensitivity to worse-than-expected states decreases the outcome advantage of deferring a reward,

$$\Delta u_{defer} = u(v_l) - \mu_{loss}u(v_s) < u(v_l) - u(v_s) = \Delta u_{neutral}, \tag{7}$$

, and increases the outcome disadvantage of speeding it up:

$$\Delta u_{speedup} = \mu_{loss}u(v_l) - u(v_s) > u(v_l) - u(v_s) = \Delta u_{neutral}, \tag{8}$$

2.5.2.2 Defer-speedup effect explained by time perception (H_{tp})

Alternatively, the defer-speedup effect could reflect that people adapt psychologically to the expected timing of the outcome [Scholten and Read, 2013]. Again, we follow the reasoning and model parameterization by Scholten & Read [2013]. Deferring a reward is treated as a loss of time in obtaining it and hypersensitivity to time lost drives up the price people demand; speeding up a reward is treated as a gain of time in obtaining it, and hyposensitivity to time gained drives down the price they offer. Formally, the time disadvantage of deferring a reward is $-\kappa_{loss}t_s^{\beta}$, where $\kappa_{loss} > 1$ is hypersensitivity to time lost (Figure 2C, bottom-left panel); the time advantage of speeding up a reward is $-\kappa_{gain}t_l^{\beta}$, where $0 < \kappa_{gain} < 1$ is hyposensitivity to time gained (Figure 2C, bottom-middle panel). Hypersensitivity to time lost increases the time disadvantage of deferring a reward,

$$\Delta p_{defer} = \kappa_{loss}p(t_l) - \kappa_{loss}p(t_s) > p(t_l) - p(t_s) = \Delta p_{neutral}, \tag{9}$$

, whereas hyposensitivity to time gained, $0 < \kappa_{gain} < 1$, decreases the time advantage of speeding it up

$$\Delta p_{speedup} = \kappa_{gain} p(t_l) - \kappa_{gain} p(t_s) < p(t_l) - p(t_s) = \Delta p_{neutral}, \tag{10}$$

2.5.2.3 Date-delay effect explained by outcome valuation (H_{ov})

The date-delay effect may arise from people preferring the precision of a date to the vagueness of a delay, letting them to assign greater value to the same option in date as compared to delay frames [Read et al., 2005]. We implement this hypothesis by assuming that valuation is boosted under calendar framing, $\mu_{boost} u(v)$, where $\mu_{boost} > 1$. Greater valuation increases the advantage of the larger-but-later option:

$$\Delta u_{date} = \mu_{boost} u(v_l) - \mu_{boost} u(v_s) > u(v_l) - u(v_s) = \Delta u_{delay}, \tag{11}$$

2.5.2.4 Date-delay effect explained by time perception (H_{tp})

Alternatively, the date-delay effect could reflect that time intervals defined by calendar dates seem shorter (i.e. time horizon is more contracted) than intervals framed in terms of a delay [Read et al., 2005, Zauberman et al., 2009]. We parameterize this by assuming that $\kappa = 1$ for delay frames and $\kappa = \kappa_{contraction} < 1$ for date frames

$$\Delta p_{date} = \kappa_{contraction} p(t_l) - \kappa_{contraction} p(t_s) < p(t_l) - p(t_s) = \Delta p_{delay}, \tag{12}$$

2.5.2.5 More complex models

While these four parameterizations result in different values for d and thus also different predictions of RT, we anticipate that the time needed to encode the stimuli will be longer for date vs. delay frames as well as for defer and speedup frames vs neutral frames. To accomodate this, we will include parameterizations in which framing conditions are not only allowed to vary in terms of value and/or time functions, but also in terms of T_{ER}.

2.5.3 Model optimization

We will fit the model parameterizations to the choice and response time data of each participant. Models will be fit by minimizing negative log-likelihood using a constrained differential evolution algorithm in R [Price et al., 2005, Mullen et al., 2011]

2.5.4 Model selection

Model selection will identify the model that best balances goodness-of-fit and complexity, based on the Bayesian Information Criterion [BIC, Schwarz and others, 1978]:

$BIC = -2logL_i + k_i logN$,

where L_i is the maximized likelihood for model i, k_i is the number of parameters in model i, and N is the number of data points. Models with more parameters have greater flexibility and can achieve higher likelihoods. The $k_i logN$ term in the equation penalizes models with greater flexibility. Models with lower BIC scores are preferred over models with higher BIC scores, as they have a better balance between goodness-of-fit and model complexity.

We will use two model selection approaches [Dai and Busemeyer, 2014, Logan et al., 2014]. The first approach is based on an aggregate BIC score. It involves summing the BIC scores across all participants and ranking the models based on the summed score. This allows us to evaluate which is the best model overall. The second approach is based on counting how often a model is selected as the best model. This allows us to evaluate consistency in the model fits across subjects.

2.5.5 Simulations

We ran a number of simulations to test the feasibility of this approach. These simulations support four main conclusions. First, the parameterizations that will be tested can account for defer-speedup and date-delay framing effects in intertemporal choice. Second, a parameter recovery simulation with a large number of trials demonstrates the accuracy of our modeling and parameter estimation code. Third, another parameter recovery simulation with representative trial numbers and model parameter values shows that best-fitting parameters approximate data-generating parameters. Fourth, a model recovery simulation shows that we can identify the data-generating model with high accuracy.

2.6 Control analyses

2.6.1 Performance on catch trials and instruction manipulation check trials

To determine whether participants paid attention to the choice options and trial instructions, we will analyze each participant's performance on catch trials (defer-speedup task, date-delay task) and instruction manipulation check trials (defer-speedup task only). If a participant's error rate, pooled across catch and instruction manipulation check trials, is greater than 25%, then we will exclude and replace that participant.

2.6.2 Effect of framing on area under the curve of successive delay-indifference point pairings

To assess whether we replicate the defer-speedup effect and date-delay effects, we will analyze how frames affect the area under the curve of successive delay-indifference point pairings. Indifference points for each delay will be derived using the best-fitting overall model and model parameters. We will compare the area under the curve between framing conditions, using one-sided Bayesian paired t-tests [Rouder et al., 2009] implemented in the BayesFactor package in R[Morey et al., 2015]. Data points that lie more than 2.5 standard deviations from the group mean are considered outliers and will be excluded from this analysis.

Priors are placed on standardized effect sizes (δ) for $H_{rep,0}$ and $H_{rep,1}$, as well as on the variance (σ^2). The standardized effect size is assumed to be 0 under $H_{rep,0}$ and distributed according to a half-Cauchy distribution with scale parameter r under $H_{rep,0}$:

$H_{rep,0} : \delta = 0$
$H_{rep,1} : \delta \; half\text{-}Cauchy(r)$

In line with the recommendation to set it equal to the standardized effect size reported in the literature [Rouder et al., 2017], we will set $r = 0.55$, (see Appendix A - Sampling plan). Following Rouder and colleagues [2012], we assume σ^2 to follow an inverse chi-square distribution with one degree of freedom.

We will perform this analysis separately for each sample (i.e. defer-speedup task, date-delay task) as soon as 20 participants have completed each task. We will repeat it after every 5 additional participants. For each task, we continue data collection until any of the following events happens:

- We find that the area under the curve is smaller for defer than neutral frames and greater for speedup than neutral frames (defer-speedup task) or greater for date than delay frames (date-delay task), as indicated by $B_{10} > 6$, reflecting that we replicate the time framing effect;

- We find that the area under the curve does neither differ between defer and neutral frames nor between speedup and neutral frames (defer-speedup task) or does not differ between date and delay frames (date-delay task), as indicated by $B_{10} < \frac{1}{6}$, reflecting that we do not replicate the time framing effect;

- We reach the maximum number of participants or the end of the data collection period, in which case we infer evidence for replication from the direction and strength of the Bayes factor [Schönbrodt and Wagenmakers, 2017].

3 Appendices

3.1 Appendix A - Sampling plan

3.1.1 Model and parameter recovery

Since our conclusion will be based on fitting performance data with stochastic, computational models, we determined how many trials we should collect (i.e. how many times each combination of experimental factors should be repeated) for model comparison and parameter estimation to be reliable, using a model recovery and parameter recovery procedure. In a model recovery procedure, synthetic data (choices and response times) are generated from each model, fit using both models, and then the resulting fits are used to decide which model generated each synthetic dataset; the accuracy of these decisions shows the reliability with which the models can be discriminated [Heathcote et al., 2015]. A parameter recovery procedure is similar, but here the synthetic data is only fit using the model with which the data were generated; the difference between the recovered parameter values and the true parameter values (with which the data were generated) provides an estimate of the bias in the parameter estimation methods (accuracy) and the uncertainty that might be present in the estimates (reliability) [Heathcote et al., 2015].

We took a four-step approach. First, for each task and model parameterization, we sampled 10 sets of model parameters from population values reported in Dai & Busemeyer [2014]. Second, for each task, model parameterization, and parameter set, we then generated synthetic datasets in which each combination of the three main experimental factors (the delay to the large-but-late option, 7 levels; the money amount of the smaller-but-sooner option, 3 levels; and, the framing, 2 levels (date-delay taslk) or 3 levels (defer-speedup task)) was repeated 2, 3, 4, or 5 times. Third, we fit the model that generated the data (e.g. model in which frames differ in terms of the value function) and the counter model (e.g. model in which frames differ in terms of the time-weighting function) to each dataset. Fourth, we assessed model recovery and parameter recovery. Model recovery was assessed by determining the frequency with which model comparison (based on the Bayesian Information Critetion) identified the correct model. Parameter recovery was assessed by comparing the values of the parameters with which the data were generated against the best-fitting parameters.

Model recovery results indicated that model selection identified the data-generating model as the best model in 94% of cases. Also, the Bayesian Information Criterion was on average always more than 10 points lower for the data-generating model than for the counter model, indicating that model selection could clearly distinguish the data-generating from the counter model. Parameter recovery results showed that differences between the data-generating parameter values and the best-fitting parameter values were typically small, even when trials were repeated only 2 or 3 times.

Based on these simulations, we decided to repeat each combination of experimental factors four times. This is sufficient for parameter and model recovery, provides a relatively fine-grained estimate of the probability of choosing either option (i.e. varying from 0.00 to 1.00 in 0.25 steps), and results in a reasonable duration of the experiment. Consequently, there will be 252 standard trials in the defer-speedup task and 168 standard trials in the date-delay task. Adding catch trials and instruction manipulation check trials, the total number of trials becomes 276 in the defer-speedup task and 184 in the date-delay task.

The duration of the entire experiment, including instructions, is approximately 45 minutes for the defer-speedup task and 30 minutes for the date-delay task.

3.1.2 Bayes Factor Design Analysis

To determine how many participants we need to collect data from, we performed a Bayes Factor Design Analysis [Schönbrodt and Wagenmakers, 2017]. Bayes Factor Design Analysis aims to facilitate the design of a study that ensures compelling evidence (i.e. high probability of obtaining strong evidence and a low probability of obtaining misleading evidence) for or against the existence of an effect. We used a particular implementation, called sequential Bayes factor design with maximal sample size [Schönbrodt and Wagenmakers, 2017]. It assumes that participants are added to a growing sample and Bayes factors are computed until a desired level of evidence or a maximum number of participants is reached. This design is efficient (i.e. allows termination of data collection when sufficient evidence has been accumulated) and can deal with

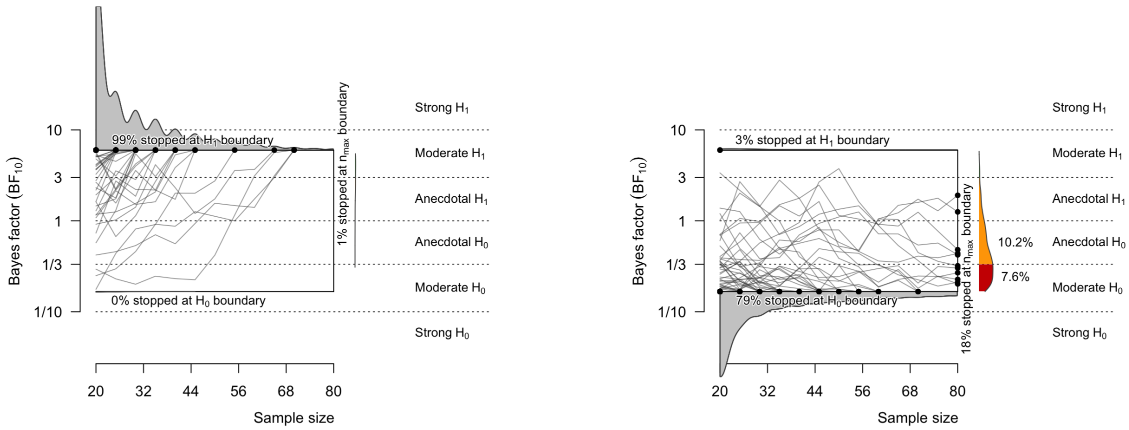

Figure 4: Bayes Factor Design Analysis results under the assumption that Hrep,1 is true (left) and under the assumption that Hrep,0 is true (right)

limited resources (time and money). It requires specification of expected effect size, desired level of evidence, maximum sample size, and further allows for defining a minimum sample size and the number of participants added to the sample between evaluating the evidence.

To determine the expected effect size, we followed the approach advocated by Halpern and colleagues [Halpern, 2002]: sample size is preferably based on an empirical definition of a practically meaningful effect, or if such a definition does not exist, an effect size estimate from previous, representative studies, or in the absence of any more specific data, a medium effect size. We are unaware of any empirical definitions of practically meaningful effects in the field of framing interventions. Koffarnus and colleagues [2013] reported effect sizes for various framing effects in intertemporal choice: the weighted average standardized effect size across across 24 studies with a total of 2461 participants was $\delta = 0.55$ (see Table below). We used this effect size in our sample size calculations and in specifying the width of the prior for Bayesian hypothesis testing.

In line with Schönbrodt & Wagenmakers [2017], we aim for a level of evidence that favors one hypothesis over the other by a factor of 6 (which has been described as evidence that is substantial [Jeffreys, 1961], positive [Kass and Raftery, 1995], or moderate [Wetzels and Wagenmakers, 2012]). Practically, this means that we will collect data until $B_{10} = 6$ or $B_{10} = \frac{1}{6}$ or until we run out of resources.

We based the maximum sample size on economic and logistic constraints: we have resources available to collect 120 hours worth of data. We plan to run two experiments (defer-speedup and date-delay tasks) with approximately equal sample sizes, hence 60 hours of data per experiment. The approximate total duration of the defer-speedup and date/defer experiment is approximately 45 minutes and 30 minutes, respectively. In other words, we need on average 37.5 minutes (0.625 hours) per participant. The maximum number of participants we can recruit per task is therefore $\frac{60}{0.625} = 96$ participants. We plan to replace participants who do not meet preset performance criteria (see Participants and Procedure). We assume that with proper task instructions, no more than 20% of participants will have to be replaced. Therefore, the maximum sample size per experiment to be used in the Bayes Factor design analysis equals, $N_{max} = \frac{96}{1.2} = 80$. We set the minimum number of participants to collect data from, N_{min}, at 20, as small(er) samples lack power to detect most effects [Simmons et al., 2011]. We will evaluate the evidence after every 5 participants added.

The results of the Bayes Factor Design Analysis are shown in Figure 4 and the notebook (https://osf.io/2kub3/). If H_1 (i.e. $H_{rep,1}$) is true, 99.3% of studies cross an evidential threshold (99.1% terminate at the H_1 boundary, 0.2% at the H_0 boundary) and 0.7% does not before reaching the maximum number of participants to be recruited ($n_{max}). Of 0.7% of studies terminating at $n_{max} = 80$, 0.3% showed evidence for H1 (BF > 3), 0.4% were inconclusive (3 > BF > 1/3), and none showed evidence for H0 (BF < 1/3). Thus, the probability of misleading evidence (favoring H_0 when H_1 is true) is 0.2%. The average sample size at termination is 30, and 80% of studies terminate before N = 35. Alternatively, if H_0 is true, 81.9% of studies cross an evidential threshold (79.2% terminate at the H_0 boundary, 2.7% at the H_1 boundary) and 18.1% does not before reaching n_{max}. Of the 18.1% of studies terminating at n_{max}, 0.3% showed evidence for H1 (BF > 3), 10.2% were inconclusive (3 > BF > 1/3), 7.6% showed evidence for H0 (BF < 1/3). Thus, the probability of misleading evidence (favoring H_1 when H_0 is true) is 2.7%. The average sample size at termination is 42, and 80% of studies terminate before N = 75.

Table 1: Effect sizes across framing studies in intertemporal choice

Study	Exp	Sample size	Manipulation	Dependent variable	Absolute effect size	Weighted effect size
Peters & Büchel, 2010	1	30	Episodic future thought	Discount rate	0.83	0.0101178
Ungemach et al., 2011	3	75	Episodic future thought between vs. not between delays	Indifference point	0.76	0.0231613
Magen et al., 2008	NA	112	Explicit-zero format (hypothetical money)	Immediate choices	0.84	0.0382284
Magen et al., 2008	NA	57	Explicit-zero format (real money)	Immediate choices	0.54	0.0125071
Radu et al., 2011	1	26	Explicit-zero format (past discounting)	Smaller proximate choices	0.80	0.0084518
Radu et al., 2011	2	47	Explicit-zero format (past discounting)	Smaller proximate choices	1.34	0.0255912
Radu et al., 2011	2	47	Explicit-zero format (future discounting)	Smaller proximate choices	0.89	0.0169972
Radu et al., 2011	4	111	Temporal priming (past discounting)	Smaller proximate choices	0.40	0.0180414
Read et al., 2005	1	58	Explicit date (months v. dates)	Delayed choices	0.75	0.0176757
Read et al., 2005	1	58	Explicit date (weeks v. dates)	Delayed choices	1.00	0.0235677
Read et al., 2005	2	160	Explicit date	Implied choices with indifference point self-report	0.59	0.0383584
Read et al., 2005	3	58	Explicit date (potentially real money)	Delayed choices	1.04	0.0245104
Read et al., 2005	4	90	Explicit date	Delayed choices	0.58	0.0212109
Read et al., 2005	5	89	Explicit date	Discount rate	0.67	0.0242300
LeBoeuf, 2006	1B	229	Explicit date	Indifference point	0.39	0.0362901
LeBoeuf, 2006	2	253	Explicit date	Specify time willing to wait	0.43	0.0442056
LeBoeuf, 2006	3	133	Explicit date	Indifference point	0.58	0.0313450
LeBoeuf, 2006	4	81	Explicit date	Amount paid to defer debt	0.62	0.0204063
LeBoeuf, 2006	5	35	Explicit date	Willingness to wait for longterm investment	1.61	0.0228972
Dai et al., 2009	1	32	Reward contrast (between subjects)	AUC	0.85	0.0110524
Dai et al., 2009	2	32	Reward contrast (between subjects)	AUC	1.00	0.0130028
Callan et al., 2009	NA	56	Perceived unfairness in watched video	AUC	0.68	0.0154734
Callan et al., 2011	1	71	Perceived unfairness (income disparity)	AUC	0.57	0.0164445
Malkoc et al., 2010	1B	521	Concrete thinking	Amount paid for immediate delivery	0.18	0.0381065
NA	NA	NA	NA	NA	NA	NA
TOTAL	NA	2461	NA	NA	NA	0.5518732

3.2 Appendix B - Instructions for participants (English)

3.2.1 Upon arrival at the Donders Institute

Hello, my name is [instructor's name]. Welcome and thank you for coming today. Let's go to the lab.

3.2.2 Upon arrival in the behavioral lab

You will notice that I will be referring to this script throughout the experiment. This is to ensure that everyone receives the same instructions.

Please, turn off your cell phone and other electronic devices that may distract you during the experiment.

3.2.3 Explanation of study purpose

Let me first tell you a little bit about the purpose of this study.

The purpose of this study is to investigate how people make choices between rewards that occur at different points in time. For example, consider a scenerio in which I would ask whether you prefer to receive a voucher worth €10 today or a voucher worth €20 in a month. In the study in which you are about to participate, we try to understand how people's choices in these types of scenarios are influenced by the way in which the scenarios are described.

To investigate this, you will perform a computer task. This task consists of a series of scenarios, each asking you to consider a pair of hypothetical money offers. For example, choose between receiving €10 today and €20 in 16 days. Your task is to indicate which option you prefer.

For date/delay task:

> *Taken together, the total duration of the study is about ... minutes*

For defer/speedup task:

> *Taken together, the total duration of the study is about ... minutes*

3.2.4 Informed consent

Do you have any questions?

Instructor answers question(s), if any

If you are still willing to participate, then please read and sign this informed consent form.

3.2.5 General instruction

Instructor launches the task in PsychoPy

Let's get started with the general instruction.

I am going to ask you to make some decisions about which of two rewards you prefer. You will not receive the rewards that you choose, but I want you to make your decisions as if you were really going to receive the rewards that you choose.

The possible rewards are presented on the left and right side of the screen. One is an immediate reward that you can get today, the other is a delayed reward that you can get after the specified amount of time.

*Here (**instructor points to the screen**) you see an example scenario*:

You can now press the right arrow to continue to the next screen.

When you do this task, it is important that you keep in mind the following:
- Read each scenario carefully, but also respond as quickly as possible;
- You will not receive the rewards that you choose, but we ask that you consider each scenario as if it was real and the only scenario you would face today;
- There are no right or wrong ways to do this task. Select the option that you prefer, not what you think I want you to prefer. I do not expect you to choose one particular reward over another. Just choose the one you really want.

You can now press the right arrow to continue to the next screen.

You will do 3 tasks in this study, all of which you will complete today:
1. *A practice task, lasting about 1 minute*
2. *A calibration task, lasting about 8 minutes*

For date/delay task:

3. *The main experiment, lasting about 12-18 minutes*

For defer/speedup task:

3. *The main experiment, lasting about 20-30 minutes*

Do you have any questions?

Instructor answers participant's questions, if any

You can now press 's' to continue to the instruction for the practice task.

3.2.6 Part 1 - Practice task

You will now perform a practice task. The purpose of this task is to familiarize you with the computer task and to provide you with the opportunity to ask questions.

I will show you a series of 10 scenarios. Each scenario asks you to choose between an immediate reward that you can get today and a delayed reward that you can get after the specified amount of time. The amount of the immediate reward will be varied between the scenarios, the other variables remain constant.

If you prefer the left option, press 'f'. If you prefer the right option, press 'j'.

You can now press the right arrow to continue to the next screen.

To start the practice task, press 's'.

3.2.7 Part 2 - Calibration task

You will now perform a calibration task. The purpose of this task is to determine the scenarios that we will show you in the main experiment.

The calibration task differs from the practice task in 3 ways:
1. *In addition to the amount of the immediate reward, the delay between the immediate and delayed reward will be varied between 2 days and 128 days;*

For date/delay task:

2. *The calibration task includes a few 'catch' scenarios designed to check whether you pay attention. In these scenarios, one option is clearly more preferable than the other;*

For defer/speedup task:

2. *The calibration task includes a few 'catch' scenarios designed to check whether you pay attention. In some scenarios, one option is clearly more preferable than the other. In others, you will be instructed to press the return key rather than choosing between the options.*
3. *At the end of the calibration task, you will receive feedback (which will be explained on the next screen)*

You can now press the right arrow to continue to the next screen.

At the end of the calibration task, you will receive feedback on your performance (**instructor points to screenshot displayed**). *To check whether you pay attention, you will be evaluated on accuracy on catch scenarios, speed of responding, and coherence of your choices.*

In the event that your performance does not meet all preset requirements, the right column of the feedback provides instructions on how you should try to improve performance (**instructor points to screenshot displayed**). *You will have to repeat the calibration task until all requirements are met. If you have not met all requirements after 2 repetitions, we will have to terminate the experiment.*

You can now press the right arrow to continue to the next screen.

For date/delay task:

You will consider 63 scenarios in the calibration task.

For defer/speedup task:

You will consider 70 scenarios in the calibration task.

While you perform the calibration task, I will be in the area at the end of the corridor. If the calibration task works out fine, just continue with the main experiment. Carefully follow the instructions you see on the screen, and you should be good to go. After the experiment is over, come see me in the area at the end of the corridor.

To start the calibration task, press 's'.

3.2.8 In case the calibration procedure fails

Your performance did not meet the preset requirements for the main experiment. You will now repeat the calibration task again. For clarity, you will be shown the instruction screens again, followed by the calibration task.

3.2.8.1 In case performance does not meet the criteria after N attempts

Unfortunately, your performance did not meet the preset requirements for the main experiment. This is nothing you need to worry about. However, it does mean that we have to terminate the study now. We will, of course, reimburse you for your participation today.

Thank you very much for your participation! Please, collect your belongings and see the experimenter now.

Your responses did not meet the preset requirements for the main experiment. This is nothing you need to worry about, but it does mean that you cannot participate in the main experiment and that we have to terminate the study now. Please, see the experimenter now.

3.2.8.2 Main experiment

You will now perform the main experiment. The purpose of this task is to determine how different scenario descriptions influence your preferences.

The main experiment differs from the previous tasks in 2 ways:
1. *For each scenario, you will have a maximum of 10 seconds to respond;*

For date/delay task:

2. *Scenarios will be presented in 2 different formats, which will be described in the following screens;*

- *A first format, with which you are already familiar, describes the time of reward delivery as a delay. Here, you see an example of this format .*

- *A second format describes the time of reward delivery as a calendar date. Here, you see an example of this format.*

For defer/speedup task:

2. *Scenarios will be presented in 3 different formats. These formats will be described in the following screens;*

- *In a first format, with which you are already familiar, you are asked to choose between an immediate reward and a delayed reward. Here, you see an example of this format.*

- *In a second format, you are told that you are scheduled to receive a reward today. You are asked to choose between: - Deferring (postponing) the reward: you will receive it later, but it will also be larger. - Receiving the reward today, as planned. Here, you see an example of this format.*
- *In a third format, you are told that you are scheduled to receive a reward later. You are asked to choose between: - Speeding up the reward: you will receive it sooner, but it will also be smaller. - Receiving the reward later, as planned. Here, you see an example of this format.*

For date/delay task: *You will consider 184 scenarios in the main experiment, 92 scenarios for each format. If you wish, you can take a short break halfway (after 92 scenarios). To start, press 's'.*

For defer/speedup task: *You will consider 276 scenarios in the main experiment, 92 scenarios for each format. If you wish, you can take a short break halfway (after 92 scenarios). To start, press 's'.*

3.2.9 Upon completing the task

You have now completed the study. Thank you very much for your participation! Please, collect your belongings and see the experimenter now.

3.2.10 Upon leaving the behavioral lab

How did it go? Did you collect all your belongings? Good, then let met escort you to the exit.

3.2.11 At the exit

You can expect the reimbursement for your participation on your bank account within 4-6 weeks. Let me know if you didn't receive it by then. Thanks again and goodbye!

3.3 Appendix C - Instructions for participants (Dutch)

3.3.1 Upon arrival at the Donders Institute

Hallo, ik ben [instructor's name]. Welkom en fijn dat je er bent. Laten we naar het lab gaan.

3.3.2 Upon arrival in the behavioral lab

Je zult zien dat ik dit script gebruik gedurende het experiment. Dit is om ervoor te zorgen dat alle deelnemers dezelfde instructies krijgen.

Zou je alsjeblieft je mobiele telefoon en andere electronische apparaten die je kunnen storen tijdens het experiment willen uitzetten.

3.3.3 Explanation of study purpose

Ik zal je eerst iets vertellen over het doel van de studie.

Het doel van de studie is om te onderzoeken hoe mensen keuzes maken tussen beloningen die op verschillende momenten in de tijd plaatsvinden. Een voorbeeld is een scenario waarin ik je vraag te kiezen tussen waardebon van €10 die je vandaag ontvangt of een waardebon van €20 die je over een maand ontvangt. In de studie waarin je gaat deelnemen proberen we te achterhalen hoe de precieze beschrijving van de scenarios keuzes beïnvloedt.

Om dit te onderzoeken zul je een computertaak uitvoeren. Deze taak bestaat uit een reeks scenarios. In elk scenario word je gevraagd te kiezen tussen twee hypothetische beloningen. Bijvoorbeeld, kies tussen een beloning van €10 vandaag en een beloning van €20 in 16 dagen. Jouw taak is om aan te geven welke beloning jouw voorkeur heeft.

For date/delay task:

De duur van de studie is ongeveer … minuten

For defer/speedup task:

De duur van de studie is ongeveer … minuten

3.3.4 Informed consent

Heb je op dit moment vragen?

Instructor answers question(s), if any

Indien je nog steeds bereidt bent tot deelname, lees en onderteken dan deze toestemmingsverklaring.

3.3.5 General instruction

Instructor launches the task in PsychoPy

Laten we beginnen met de algemene instructie

Ik ga je vragen om keuzes te maken tussen twee beloningen. Je krijgt deze beloningen niet echt, maar ik wil dat je je keuzes maakt alsof je deze beloning die je kiest daadwerkelijk zou krijgen.

De beloningen die je kunt ontvangen staan links en rechts op het scherm afgebeeld. Een van de beloningen kun je direct ontvangen, de andere beloningen kun je op een later moment ontvangen.

*Here (**instructor points to the screen**) you see an example scenario*:

Je mag nu op het rechterpijltje drukken om naar het volgende scherm te gaan.

Tijdens het uitvoeren van de taak is het belangrijk dat je het volgende in acht neemt:
- Lees elk scenario zorgvuldig, maar reageer ook zo snel als je kunt; - Je krijgt de beloningen die je kiest niet, maar neem ieder scenario in overweging alsof het echt is en het enige scenario dat je vandaag in overweging neemt;
- Er is geen juiste of onjuiste manier om deze taak te doen. Kies de beloning die jouw voorkeur heeft, niet de beloning waarvan je denk dat ik wil dat jij die kiest. Ik verwacht niet dat je een bepaalde beloning verkiest boven een andere. Kies simpelweg de beloning die jij echt zou willen ontvangen.

Je mag nu op het rechterpijltje drukken om naar het volgende scherm te gaan.

Je gaat vandaag 3 computertaken uitvoeren:
1. *Een oefentaak, die ongeveer 1 minuut duurt;*
2. *Een calibratietaak, die ongeveer 8 minuten duurt;*

For date/delay task:

3. *Het hoofdexperiment, dat ongeveer 12-18 minuten duurt.*

For defer/speedup task:

3. *Het hoofdexperiment, dat ongeveer 20-30 minuten duurt.*

Heb je nog vragen?

Instructor answers participant's questions, if any

Je mag nu op de letter 's' drukken om door te gaan naar de instructie voor de oefentaak..

3.3.6 Part 1 - Practice task

Je gaat nu de oefentaak uitvoeren. Het doel van deze taak is om jouw bekend te maken met de computertaak en om je de mogelijkheid te bieden verdere vragen te stellen.

Ik zal je een reeks van 10 scenarios laten zien. In elk scenario word je gevraagd te kiezen tussen een beloning die je direct ontvangt en een beloning die je op een later moment ontvangt. De hoogte van de beloning die je direct ontvangt varieerd tussen de scenarios, the andere aspecten blijven gelijk.

Indien je voorkeur uitgaat naar de beloning links op het scherm, druk dan op de letter 'f'. Indien je voorkeur uitgaat naar de beloning rechts op het scherm, druk dan op de letter 'j'.

Je mag nu op het rechterpijltje drukken om naar het volgende scherm te gaan.

Om de oefentaak te beginnen, druk op de letter 's'.

3.3.7 Part 2 - Calibration task

Je gaat nu de calibratietaak uitvoeren. Het doel van deze taak is om de scenarios te bepalen die je in het hoofdexperiment te zien krijgt.

De calibratietaak verschilt van de oefentaak op 3 punten:
1. *Naast de hoogte van de beloning die je direct ontvangt, zal ook de tijd tussen de directe en latere beloning worden gevarieerd, namelijk tussen 2 en 128 dagen;*

For date/delay task:

2. *De calibratietaak bevat een aantal zogenaamde 'catch' scenarios die ontworpen zijn om te bepalen of je goed oplet. In deze scenarios is één van de opties duidelijk aantrekkelijker dan de andere.*

For defer/speedup task:

2. *De calibratietaak bevat een aantal scenarios die ontworpen zijn om te bepalen of je goed oplet. In deze scenarios is één van de opties duidelijk aantrekkelijker dan de andere. In een ander type scenario word je gevraag op op de 'return' toets te drukken in plaats van te kiezen tussen de twee opties.*

3. *Aan het einde van de calibratietaak zul je feedback ontvangen, waarover meer wordt uitgelegd op het volgende scherm.*

Je mag nu op het rechterpijltje drukken om naar het volgende scherm te gaan.

Aan het einde van de calibratietaak zul je feedback ontvangen (**instructor points to screenshot displayed**). *Je zult worden geevalueerd op je prestatie op de 'catch' scenarios, hoe snel je reageert, en de coherentie van je keuzes.*

Indien jouw prestatie niet voldoet aan de gestelde eisen, geeft de rechterkolom aan hoe je de taak uitvoering van de taak kunt verbeteren (**instructor points to screenshot displayed**). *Je zult de calibratietaak moeten herhalen, totdat je aan alle eisen voldoet. Indien je na twee keer herhalen nog niet voldoet aan deze eisen kun je niet deelnemen aan het hoofdexperiment, en wordt de studie beëindigd.*

Je mag nu op het rechterpijltje drukken om naar het volgende scherm te gaan.

For date/delay task:

De calibratietaak bestaat uit 63 scenarios.

For defer/speedup task:

De calibratietaak bestaat uit 70 scenarios.

Terwijl jij de calibratietaak doet, ben ik in de ruimte aan het einde van de gang. Als de calibratietaak goed verloopt mag je doorgaan met het uitvoeren van het hoofdexperiment. Lees de instructies voor het hoofdexperiment die op het scherm verschijnen zorgvuldig. Als je klaar bent met het hoofdexperiment, kom mij dan opzoeken in de ruimte aan het einde van de gang.

Om de calibratietaak te beginnen, druk op de letter 's'.

3.3.8 In case the calibration procedure fails

Jouw prestatie voldoet niet aan de gestelde eisen voor het hoofdexperiment. Je gaat nu de calibratietaak nogmaals uitvoeren. Ter verduidelijking krijg je eerst de instructies nogmaals te zien. Vervolgens doe je de calibratietaak opnieuw.

3.3.8.1 In case performance does not meet the criteria after N attempts

Helaas voldoet je prestatie niet aan de vooraf gestelde eisen voor het hoofdexperiment. Maak je er geen zorgen over. Het betekent echter wel dat we de studie nu beëindigen. Uiteraard krijg je wel een vergoeding voor je deelname.

Heel erg bedankt voor je deelname. Vergeet je spullen niet, en meldt je nu nij de onderzoeker.

3.3.8.2 Main experiment

Je gaat nu het hoofdexperiment doen. Het doel van dit experiment is om te bepalen hoe verschillende beschrijvingen van een scenario keuzes beïnvloeden.

Het hoofdexperiment verschilt van de vorige taken op 2 punten:
1. *Je hebt maximaal 10 seconden per scenario om een keuze te maken;*

For date/delay task:

2. *Er zijn 2 scenario formats, welke worden beschreven in de volgende schermen;*

- *In het eerste format, waarmee je al bekend bent, wordt het moment van de beloning omschreven als het aantal dagen dat het duurt voor je de beloning ontvangt. Hieronder zie je een voorbeeld.*
- *In het tweede format wordt het moment van de beloning omschreven als een datum waarop je de beloning ontvangt. Hieronder zie je een voorbeeld.*

For defer/speedup task:

2. *Er zijn 3 scenario formats, welke worden beschreven in de volgende schermen;*

- *In het eerste format, waarmee je al bekend bent, kies je tussen een beloning die je direct ontvang en een beloning die je op een later moment ontvangt. Hieronder zie je een voorbeeld.*
- *In het tweede format wordt je verteld dat je vandaag een beloning zult ontvangen. Vervolgens heb je de keuze tussen: - het uitstellen van deze beloning: je krijgt de beloning dan later, maar deze is ook hoger. - het ontvangen van de beloning op het geplande moment.*
- *In het derde format wordt je verteld dat je op een later moment een beloning zult ontvangen. Vervolgens heb je de keuze tussen: - het versnellen van deze beloning: je krijgt de beloning dan vandaag, maar deze is ook lager. - het ontvangen van de beloning op het geplande moment.*

For date/delay task: *Je krijgt in totaal 184 scenarios te zien, 92 scenarios van ieder format. Als je wil kunt je halverwege een korte pauze nemen. Om te beginnen met het hoofdexperiment, druk op de letter 's'.*

For defer/speedup task: *Je krijgt in totaal 276 scenarios te zien, 92 scenarios van ieder format. Als je wil kunt je op eenderde en tweederde van de taak een korte pauze nemen. Om te beginnen met het hoofdexperiment, druk op de letter 's'.*

3.3.9 Upon completing the task

Je bent klaar met het experiment. Heel erg bedankt voor je deelname. Vergeet niet je spullen mee te nemen.

3.3.10 Upon leaving the behavioral lab

Hoe ging het? Heb je al je spullen? Ok, dan wijs ik je nu de weg naar de uitgang.

3.3.11 At the exit

Je kunt de vergoeding van je deelname binnen 4-6 weken verwachten op je bankrekening. Laat me weten als je het dan nog niet hebt ontvangen. Nogmaals bedankt voor je deelname!

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