

## Research Report

# The Effect of Delay Duration on Delay Discounting Across Adulthood

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## Abstract

**Objectives:** Literature about the relationship between age and delay discounting, or the willingness to wait for delayed rewards, is mixed. We posit that some of this heterogeneity may be attributable to inconsistent delay durations across studies. Here we investigate how delay duration influences discounting across adulthood by systematically varying the duration of the delay between the smaller, sooner and the larger, later option.

**Methods:** 288 healthy participants (age range: 25–84 years) completed an online delay discounting task that probed 12 different time delays across 3 discount rates. Discounting was analyzed in 2 statistical models that treated delay duration as either a categorical or a continuous predictor.

**Results:** Longer delays were generally associated with decreased discounting. However, this was dependent on both age of the participant and delay duration. Both models revealed that, at short to moderate time delays, older adults discounted less than younger adults. However, at very long delays (5 and 10 years), older adults discounted at similar rates to younger adults.

**Discussion:** Results suggest that delay length can moderate the relationship between age and discounting. Using delays longer than those tested here (>10 years) could reveal yet another trend (i.e., a reversal) to those found here. Future research should investigate whether this reversal in discounting exists, why it exists, and where the inflection point lies.

**Keywords:** Cognition, Decision making, Life course and developmental change

Should I spend that bonus from work on a vacation now, or should I put it toward my future retirement? Studies suggest that when considering the value of a reward at two different time points (i.e., future or now), people tend to devalue, or to discount the value, of the later reward. This devaluation of future rewards is known as delay discounting and it varies from person to person.

Age has been proposed as one variable to explain this variance in delay discounting. One prominent theory of aging, Socioemotional Selectivity Theory (SST), states that younger people seek novel experiences to enrich themselves,

whereas with age, people prefer more familiar, emotionally meaningful experiences (Carstensen, 1992; Fung & Carstensen, 2004). These shifting priorities are putatively driven by age-related changes in Future Time Perspective (FTP). As people age and begin to perceive their time as limited, they may gravitate more toward immediate payoffs. Therefore, SST and FTP would predict that older adults may discount more steeply as they have less time to enjoy—or even realize—a delayed reward (Löckenhoff, 2011). However, the empirical literature has consistently shown mixed age effects. Some studies find significant decreases

in discounting with age (Eppinger et al., 2012; Green et al., 1994), others find significant increases in discounting with age (Huffman et al., 2019; Read & Read, 2004), and still others do not show any age effects at all (Löckenhoff & Samanez-Larkin, 2020; Seaman et al., 2018). A recent systematic review and meta-analysis provides greater detail on the heterogeneity in the literature (Seaman et al., in press).

We posit that one of the reasons for these mixed findings is that prior studies have not systematically varied the time interval between the smaller, sooner and larger, later option. Prior studies have used time intervals ranging from hours to years. According to SST, we would expect that longer delays would lead to greater discounting in older adults. To the best of our knowledge, only two studies have explicitly investigated the effect of delay duration on discounting behavior with age and found mixed results. Löckenhoff and Samanez-Larkin (2020) found no age differences when examining discounting for months or year delays, while Richter and Mata (2018) found increased discounting with age that was more pronounced at 12-month delays than at 1-month delays. Given the very different delay lengths used in these prior studies and their disparate results, we decided to focus on the effect of delay length on discounting across adulthood.

This study investigated how delay duration influenced delay discounting across the life span by systematically varying the delay duration for the larger, later option. We hypothesized that (a) across all ages, we would see less discounting with longer time delays, and (b) age differences in discounting would only appear with longer time delays, with older adults discounting more than younger adults only for long delays (years) due to their perception of limited future time.

## Method

### Participants

Participants ( $N = 288$ , age:  $M = 54.37$ ,  $SD = 16.68$ , range = 25–84) completed an online study using Qualtrics Panels. An a priori power analysis with  $\alpha = 0.05$  and power = 0.80 indicated that the minimum sample size needed to observe a small-to-medium interaction effect between two age groups with four delay conditions was 274. The sample was collected in six equally sized age bins, each with an equal number of men and women in each bin. Across the entire sample, participants were recruited to match the racial diversity described in the most recent U.S. Census. Screening questions were used to exclude individuals with psychological or neurological health issues. The Institutional Review Board at the University of Texas at Dallas approved all experimental procedures.

### Experimental Procedures

After consenting, participants completed a demographic survey, a delay discounting practice round and task, and

two other questionnaires not reported here. The total survey time was approximately 7 min.

### Delay Discounting Task

In the delay discounting task, participants choose between a smaller amount of money today (smaller, sooner option) and a larger amount of money in the future (larger, later option). In this task, the key manipulation was varying the time interval (or delay) between the smaller, sooner option and the larger, later option. Sample items included “Which option would you prefer: \$10 today or \$13.50 in 7 days?”

The delay discounting task was comprised of two practice trials, 36 task trials, and four attention checks. A combination of 12 time intervals (1 day, 4 days, 7 days, 1 week, 2 weeks, 4 weeks, 1 month, 6 months, 12 months, 1 year, 5 year, and 10 years) and three hypothetical discount rates (of  $k = 0.1$ ,  $k = 0.05$ , and  $k = 0.005$ ) were used to create the 36 delay discounting trials. In order to estimate an appropriate future monetary amount that corresponded to these time delays at these discount rates, a hyperbolic discounting formula was used. Discounting was measured as the proportion of smaller, sooner options chosen; see [Supplementary Material](#) for more details.

### Data Analysis

All statistical analyses were conducted in R version 1.2.5033. Both hypotheses (H1: less discounting with longer time delays across all ages and H2: older adults discounting greater than younger adults for long time delays) were tested in two statistical models. Model 1 treated time delay as a categorical variable; it was a one-way (time delays: days, weeks, months, years) analysis of covariance with age as a continuous covariate on the proportion of sooner options. When the assumption of sphericity was violated, Greenhouse–Geisser corrections were used. Model 2 treated time delay as a continuous variable; it was a logistic regression using time delay (in days) and age (in years) to predict the choice (smaller, sooner or larger, later) on each trial. The main effect of delay in either model, such that longer delays lead to less discounting, would provide evidence supporting H1. An interaction between delay and age in either model, with longer delays leading to greater discounting only for older individuals, would provide evidence supporting H2. Our continuous measure of delay used in Model 2 was positively skewed, so we used a log-transformation on this variable in all data analyses and then all assumptions for parametric analyses were met.

### Changes From Preregistration

The preregistered sample size was 276 participants (rounded up from 274 to foster equal numbers in each age bin), with 46 participants per age bin. During recruitment, panels incremented quotas by two participants per bin to buffer against any incomplete or

low-quality responses. This led to a final sample size of 288 participants. Additionally, the survey used four catch trials instead of the three that were preregistered.

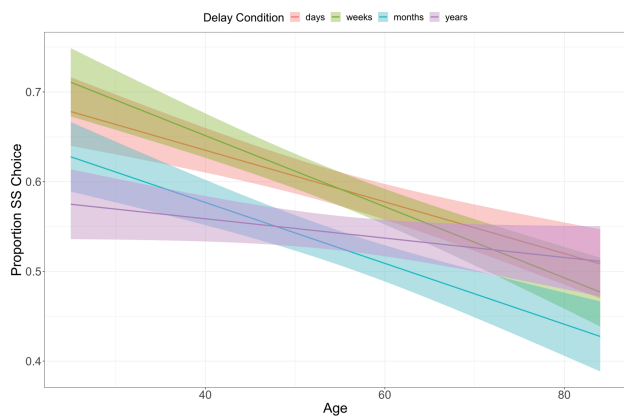
Our preregistered first hypothesis was that across all ages, we would see *greater* discounting with longer time delays. However, this hypothesis is not supported by prior research, which clearly suggests the opposite: less discounting with longer time delays (Frederick & Loewenstein, 2002). We have rephrased the hypothesis to be more consistent with prior studies, but note that this is not the hypothesis that was preregistered.

## Results

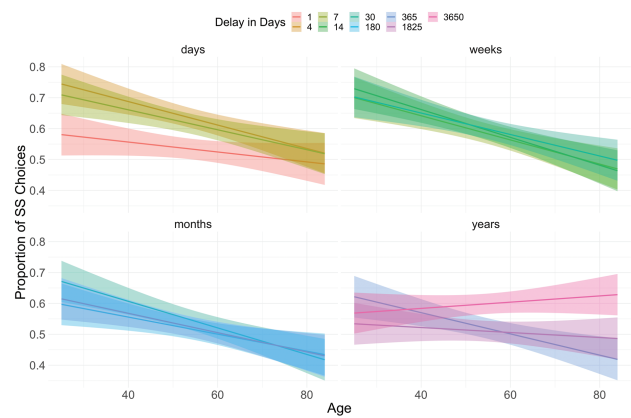
Here we report the results of both Model 1, where delay was treated as a categorical predictor (i.e., *days*, *weeks*, *months*, and *years*), and Model 2, where delay was treated as a continuous predictor (i.e., *days*). Age was treated continuously in all models.

### Across All Ages, Do Longer Time Delays Increase Discounting?

Both models suggested a significant relationship between the duration of a delay and discounting behavior (Figures 1 and 2). Longer delays were generally associated with decreased discounting. Controlling for age, in Model 1, there was a significant main effect of delay on proportion of sooner options chosen,  $F(3, 858) = 10.72$ ,  $p < .001$ ,  $\eta_G^2 = 0.008$ . Paired  $t$ -tests revealed greater discounting for days and weeks compared to months and years (Supplementary Table S2). Similarly, Model 2 also demonstrated a significant main effect of delay on choice ( $B = -0.113$ ,  $\beta = -0.153$ ,  $p < .001$ ), such that discounting declined as delay length increased. It is important to note, however, that these main effects were conditioned by significant age  $\times$  delay interactions.



**Figure 1.** Delay discounting by delay unit across adulthood. The proportion of sooner options chosen by age and length of delay (days, weeks, months, or years). Higher values represent more discounting. Error bars reflect the 95% confidence interval.



**Figure 2.** Delay discounting by delay (in days) across adulthood. The proportion of sooner options chosen by age and length of delay (in days). Higher values represent more discounting. Graphs are faceted by the unit that was presented to participants (days, weeks, months, or years). The length of 7 days is shown on the Days and Weeks graph, representing data from when this length was presented to participants as 7 days (Days facet) and 1 week (Weeks facet). Similarly, 30 days appear on the Weeks (4 weeks) and Months (1 month) graphs while 365 days appear on Months (12 months) and Years (1 year) graphs. Error bars reflect the 95% confidence interval.

### Do Older and Younger Adults Differ in How Longer Time Delays Affect Discounting?

Contrary to our predictions, both models showed older adults discounting *less* than younger adults at moderate delays. However, Model 2 provided some limited support for our hypothesis, but the effect was not as strong as predicted.

In Model 1, there was a significant age  $\times$  delay interaction  $F(3,858) = 3.93$ ,  $p = .03$ ,  $\eta_G^2 = 0.02$ , with a significant decline in discounting with age for days, weeks, and months, but not for years (Supplementary Table S2). Model 2 revealed a slightly more nuanced picture. In this model, there was also a significant age  $\times$  delay interaction ( $B = 0.002$ ,  $\beta = 0.014$ ,  $p < .001$ ). As in Model 1, older adults discounted *less* than younger adults at all but the longest delay durations (Figure 2; Supplementary Table S3). At the longest delays (5 and 10 years), older adults discounted at similar rates as their younger counterparts. These results remain significant when controlling for discount rate and delay label (Supplementary Figure S1; Supplementary Tables S4–S6).

## Discussion

This study investigated the relationship between delay duration and delay discounting across the adult life span. There are three main findings. There was a general decrease in discounting as the duration of delay increased, and there was a significant decline in discounting with age. However, this age-related decline in discounting varied by delay length. Generally, older adults tended to discount less than younger adults for short to moderate delays, but

discounted at the same rate as younger adults at the longest delays of 5 and 10 years.

The finding that there is a general decrease in discounting as delay length increases is largely consistent with prior studies of temporal discounting (Frederick & Loewenstein, 2002; Thaler, 1981). One explanation for this is the perceived time-based account of temporal discounting (Kim & Zauberman, 2009). This account posits that *perception of delays*—specifically, diminishing sensitivity to longer time horizons—causes reduced discounting for longer time delays. In other words, people perceive longer delays as being shorter than they actually are, which leads people to discount at lower rates for longer delay lengths.

Our second result, a significant decline in discounting with age, is also consistent with early discounting studies (Green et al., 1994). However, this result is at odds with more recent work (Read & Read, 2004; Seaman et al., 2016). In fact, a recent meta-analysis did not find a sizeable relationship between age and intertemporal discounting (Seaman et al., in press). The meta-analysis documents the large heterogeneity in theory, methods, and empirical results, which can make comparing studies difficult. It is possible that some other factors, like socioeconomic status, led older individuals in the sample to discount less than younger adults. For instance, Green et al. (1996) found that wealthy older adults discounted less than older adults of a lower socioeconomic status. However, given that older individuals in our sample had lower incomes than younger adults (Supplementary Table S1), this explanation is unlikely. It is possible there is some unmeasured difference, like cognitive ability, that could explain the observed group differences.

The results are somewhat consistent with our second hypothesis that older adults discount more than younger adults at very long delays. This hypothesis presumed that discounting would be consistent across adulthood for shorter delays, but as noted above, in this sample discounting *decreased* with age for short delays. This trend appears to begin to reverse at the longest delay lengths (5 and 10 years), suggesting that using even longer delays—over 10 years—may reveal age differences consistent with our hypothesis. More research is needed with different samples and longer time delays. These results are somewhat consistent with Löckenhoff and Samanez-Larkin (2020), who found no effect of delay length (months vs. years) on age differences in discounting. However, they averaged across multiple delay lengths (2, 4, 6, 8, and 10 months and years, respectively), which could have obscured a more nuanced delay effect. Our results dramatically differ from Richter and Mata (2018), who found increased discounting in older adults at longer, compared to shorter, delays. Richter and Mata (2018) employed much shorter delays: they compared 1-month delays to 12-month delays. We found that older adults discounted less than younger adults for these two delay points (Figure 2; Supplementary Table S4). It is likely that differences in study design contributed

to these differences, as Richter and Mata (2018) measured discounting using 20 different amounts for the same time delay whereas we only used three amounts per time delay.

As noted above, one limitation of all studies is that the delay durations used may be too short; delays longer than 10 years may be necessary to see a reversal in discounting for older individuals. Future research may wish to employ longer time delays. Furthermore, analysis using the Simonsohn two-lines test (Simonsohn, 2018) could be used to determine inflection point, or the delay durations at which older adults switch from discounting less than younger adults to discounting more than younger adults, if there is such an inflection point.

While our results are promising, they should be interpreted with caution. Prior studies examining delay duration in aging have shown mixed results (Löckenhoff & Samanez-Larkin, 2020; Richter & Mata, 2018). Our results should be replicated and extended prior to drawing strong conclusions. As our study was conducted online, we were unable to conduct cognitive assessments to characterize the cognitive abilities in our sample. Therefore, it is impossible to rule out cognitive ability as a confound. Additionally, although there is little evidence that incentives affect age effects on discounting (Seaman et al., in press), future studies could benefit from using real (rather than hypothetical) rewards. Research has shown that the decision preferences of older adults may differ based on the type of reward more than that of younger adults (Horn & Freund, 2021; Jimura et al., 2011; Seaman et al., 2016). For example, when offered hypothetical rewards, older adults had lower value maximization and were less consistent in their preferences than younger adults were; yet these differences disappeared when real rewards were promised (Horn & Freund, 2021). The differential effect of hypothetical rewards across ages could have played a role in our results. Finally, as the research is cross-sectional, it is difficult to disentangle cohort effects from true age effects. Longitudinal studies of decision making are needed to truly understand how decision preferences, like delay discounting, change across the adult life span.

Delay discounting has great implications for how individuals prepare for their future. If older adults do indeed discount more steeply for extremely long delays—longer than the delays measured here—then it is important to investigate the practical significance of this preference. Opting for a smaller, sooner reward instead of a very delayed one could potentially be advantageous if the later reward were to arrive after the end of a life span. Conversely, if the later reward were to arrive at a point where it could be enjoyed, this preference could potentially be detrimental. Our results suggest that older adults are sensitive to the duration of time delays and that their preferences may change, or perhaps reverse, at longer delays. Thus, consideration should be given to the duration of time delays when investigating discounting across the adult life span.

## Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences* online.

## Funding

None reported.

## Conflict of Interest

None declared.

## Data Availability

Preregistration, de-identified data, analysis scripts, and data products for this study are publicly available on OSF: <https://osf.io/9cjmn/>

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