Supplement: The Effect of Delay Duration on Delay Discounting across Adulthood

Methods

Participants

Screening. In an attempt to recruit a cognitively healthy sample in an online format, we used the following screening questions: “Are you currently experiencing, or have you previously experienced any neurological health issues (for example, seizure, stroke, dementia, Alzheimer's, Parkinson's, etc.)?” and “Are you currently experiencing or have you previously experienced any psychological health issues (for example, depression, bipolar, anxiety, OCD, ADD/ADHD, eating disorder, addiction, etc.)?” If potential participants responded affirmatively to either one of these screening questions, they were deemed ineligible to participate.

Recruitment and Sample Composition. Additionally, to recruit a balanced sample (by age bins and by gender), we asked participants about their age and their gender in the screening question cluster. The sample was subdivided into six age bins (i.e., 25-34, 35-44, … ,75-85), each containing an equal number of participants (i.e., 48), and an equal number of men and women (i.e., 24). Qualtrics terminated recruitment for a given compositional bin when the target sample size for that bin was reached.

To recruit a sample that was representative of the US, we sought to recruit a sample that matched the racial demographics found in the most recently available Census (2010 at that time): 72% White, 13% Black, 5% Asian, 1% American Indian/ Alaska Native, 9% Another Race (including Multiracial, and Native Hawaiian/ Pacific Islander). Our final sample matched that distribution exactly.

Table S1
Demographic Data

	Older[a]	**Younger**[a]
N	144	144
Age	68.94 (7.43)	39.73 (8.56)
Education[b]	3.73 (1.52)	3.97 (1.6)
Income[c]	5.61 (3.77)	7.03 (4.7)
Physical Health[d]	3.42 (0.92)	3.56 (0.98)
Sex	F = 72, M = 72	F = 72, M = 72
Race	American Indian/ Alaska Native = 2, Asian = 5, Black/African American = 11, Multiracial = 2, Other = 2, White/Caucasian = 122	American Indian/ Alaska Native = 1, Asian = 9, Black/African American = 27, Multiracial = 6, Other = 16, White/Caucasian = 85

[a] Age groups created via median split
[b] Education categories: *1* = middle school, *2* = high school diploma, *3* = some college, *4* = associate degree, *5* = bachelor’s degree, *6* = master’s degree, *7* = professional/doctoral degree
[c] Income binned in \$10,000 increments, ranging from *1* = “less than \$10,000” to *16* = “\$150,000 or more”.
[d] Physical health: ranked on scale from *1* = “not at all healthy” to *5* = “very healthy”; self-reported

Table S1. Demographic data of sample. Age groups created by median split.

Experimental Procedures

Future Time Perspective Scale. Future Time Perspective (FTP) is the subjective perception of how much time one feels that they have left to live, and could mediate the relationship between age and discounting behavior. Participants completed the English version of The Future Time Perspective Scale (Carstensen & Lang, 1996). The score is the average rating of 10 items and ranges from 1 to 7.

Generating the Delay Discounting Task. As referenced in the manuscript, a combination of 12 time-intervals and 3 hypothetical discount rates were used to create the 36 delay discounting trials where an individual discounting at that specific rate would be indifferent between the two options presented. 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: reward=SV * (1+ k*delay). In this model, SV (subjective value) is the dollar amount of the reward today (set to $10 in every trial), reward is the dollar amount in the future after a given time delay, k is the discount rate, and delay is the time delay (in days). For this function, a month was operationalized to be 28 days, so the time intervals used were: 1 day, 4 days, 7 days, 14 days, 28 days, 180 days, 365 days, 1825 days, 3650 days. The discount rates of k= 0.1, k= 0.05, and k=0.005 were used.

A complete list of the combinations of presented time intervals, discount rates, and monetary amounts offered can be found on our OSF page (https://osf.io/9cjmn/), under Stimuli and Materials in the varyDelayStimuli.xlsx file.

Presentation of the Discounting Task. During the task, participants were presented with questions about each delay duration three times (with differing future reward amounts corresponding to the three hypothetical discount rates) to create 36 trails. For example: “Which option would you prefer: $10 today or $10.70 in 2 weeks?”, or “Which option would you prefer: $10 today or $17 in 2 weeks?”, or “Which option would you prefer: $10 today or $24 in 2 weeks?”. Delay lengths were always presented to participants as the following: “1 day, 4 days, 7 days, 1 week, 2 weeks, 4 weeks, 1 month, 6 months, 12 months, 1 year, 5 years, and 10 years”.

The survey also included four catch trials or attention checks. These attention checks, unlike the other items in the delay discounting task, had a correct and an incorrect answer. An example is: “Would you prefer $10 Today or $5 Tomorrow?” Qualtrics Panels automatically excluded participants who failed a catch trail and participants who did not provide an answer to every question in the survey. The researchers did not further exclude any participants from the data provided by Qualtrics Panels.

The 36 discounting trials and four catch trials were randomly presented to participants throughout the task.

Framing Effects in Delay Discounting Task. Some of the presented delay durations were equivalent (i.e., 7 days and 1 week, 4 weeks and 1 month, 12 months and 1 year). To investigate our framing hypotheses, we compared the choices made on trials with equivalent delay lengths presented in different delay units. For example, we compared the choices made for “Which option would you prefer: $10 today or $38 in 4 weeks?” and “Which option would you prefer: $10 today or $38 in 1 month?”

Data Analysis

All statistical analyses were conducted in R version 1.2.5033 and were conducted using very common packages (e.g., plyr, tidyverse, here, stats, and ggplot). All packages used are listed at the top of each script.

It should also be noted that while the sample was recruited using discrete age bins to ensure a well-balanced sample, age was treated continuously in both analysis models, including the ANCOVA. It is also important to note that delays lengths were transformed into *days* for data analysis and presentation (i.e., in Model 2 and Figure 2).

Results

Model 1 Follow-up Tests

We conducted post hoc testing by age group, using Tukey's Honest Significant Difference to correct for multiple comparisons. Supplemental Table 2 demonstrates that there were not significant differences between shorter delays (days and weeks) and longer delays (months and years). Further, it shows that shorter delay lengths (days, weeks, months) were significantly *negatively* correlated with age.

Table S2

Mean, standard deviation and correlations with age of proportion of smaller, sooner (SS) options selected by delay length in units

Delay Length in Units	*SS Choice*	*Std. Deviation*	*Paired t-test*			*Correlation with Age*
			Weeks	*Months*	*Years*	
Days	0.59	0.49	0.936	< .001	< .001	-0.148*
Weeks	0.59	0.49		<.001	< .001	-0.201***
Months	0.53	0.50			0.156	-0.166**
Years	0.54	0.50				-0.05

Model 2 Follow-up Tests

We conducted bivariate correlations by delay length in days to better understand the impact of delay length on the correlation between age and discounting. We found that there was a significant, negati ve correlation for most small delay lengths (5-365 days), but no correlation with age for longer dela ys (1825 and 3650 days or 5 and 10 years).

Table S3

Mean, standard deviation and correlations with age of proportion of smaller, sooner (SS) options selected by delay length in days

Delay Length in Days	*SS Choice*	*Std. Deviation*	*Correlation with Age*
1	0.53	0.50	-0.054
4	0.63	0.48	-0.131***

7	0.60	0.49	-0.121***
14	0.60	0.49	-0.153***
30	0.57	0.49	-0.131***
180	0.52	0.50	-0.092**
365	0.52	0.50	-0.109***
1825	0.51	0.50	-0.027
3650	0.60	0.49	0.034

Exploratory Analyses

Future Time Perspective. For the trials with the longest delay (i.e *10 years*), we tested whether Future Time Perspective (FTP) statistically mediated the relationship between age and choice. Although age was a significant predictor of FTP (*B*= -.022, *beta* = -.210, $p < .001$), FTP was not a significant predictor of choice (*B* = -.003, *beta*= -.002, $p = .82$). Thus, FTP did not statistically mediate the relationship between age and choosing the smaller, soon option for delays of 10 years. See mediation model below.

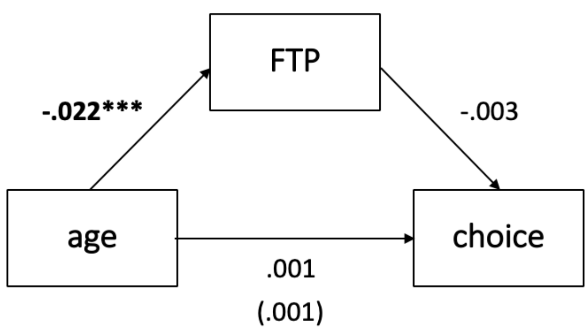


*Figure S2. Unstandardized regression coefficients for the relationship between age and choice, as mediated by future time perspective. The unstandardized regression coefficient for the relationship between age and choice, controlling for FTP is in parentheses. Note: ***p < .001*

Framing Effects. Does the description, or framing of a delay, influence discounting behavior? For example, does the description "1 week" vs "7 days" affect the proportion of sooner options chosen?

We did not find strong evidence for the influence of description, or framing, on choice behavior. Controlling for age, frame was only significant for one of three levels: framing the delay as "*4 weeks*" instead of "*1 month*" increased discounting. The other frames (i.e: *12 months* vs *1 year*, and *7 days* vs *1 week*) had no significant effect on discounting (all $p > .05$, see table below).

Table S4: Framing Effects

Frame	Results
7 days vs *1 week*	*B* = .06, *p* = .55
4 weeks* vs *1 month	***B* = .21, *p* = .01**
12 months vs *1 year*	*B* = .05, *p* = .51

Previous research has found that presenting time in days, rather than in larger units, leads to differences in behavioral responses (Lewis & Oyserman, 2015). We only observed a slight framing effect where "*4 weeks* vs. *1 month*" produced slightly more discounting for the former option. It is unclear why we did not observe a larger effect, but it may be that this type of framing has little impact on discounting. Date framing, or presenting a specific date rather than a delay duration, has shown to more consistently affect discounting behavior (Rung & Madden, 2018).

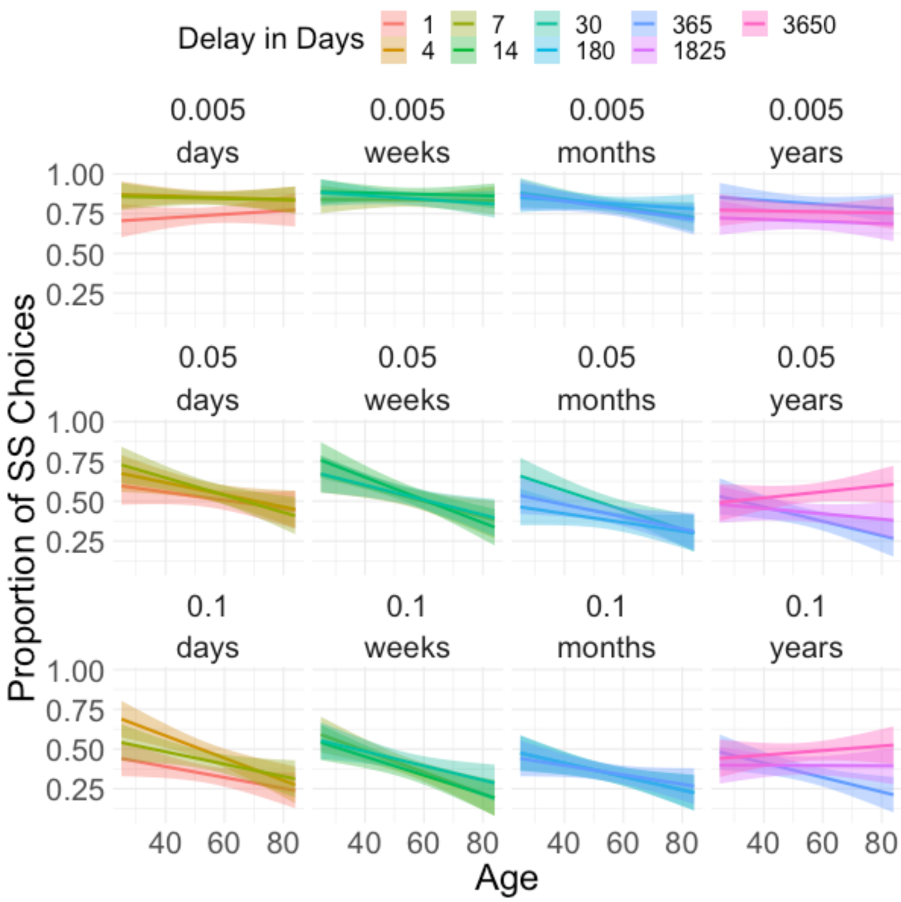
Discount Rate. Does the discount rate influence discounting behavior? Prior studies suggest that this could be the case. We found strong effects of discount rates in our data – both main effects and interactions. Critically, the three-way interaction between age, delay length in days, and discount rate was significant.

Table S5 Table for Linear Model Comparison

	Dependent variable:	
	Choice	
	Original	Discount Added
Age	-0.014^{***}	-0.007^{**}
	(-0.017, -0.012)	(-0.012, -0.002)
Delay in Days	-0.0003^{***}	-0.0002^{*}
	(-0.0004, -0.0002)	(-0.0005, -0.00000)
Discount Rate		-11.227^{***}
		(-15.521, -6.933)
Age x Delay in Days	0.00001^{***}	0.00000
	(0.00000, 0.00001)	(-0.00000, 0.00001)
Age x Discount Rate		-0.168^{***}
		(-0.245, -0.092)
Delay in Days x Discount Rate		-0.002
		(-0.005, 0.002)
Age x Delay in Days x Discount Rate		0.0001^{*}
		(0.00002, 0.0001)
Constant	1.053^{***}	1.747^{***}
	(0.901, 1.205)	(1.456, 2.038)
Observations	10,368	10,368
Log Likelihood	-7,041.090	-6,399.240
Akaike Inf. Crit.	14,090.180	12,814.480
Note:	*p<0.05; **p<0.01; ***p<0.001	

Visualization of the data by k-value shows that the trends are most consistent for larger k-values (kvalue = 0.05, 0.1, bottom two rows) and that change in the trend of age appears in these large k-values as well (last column, bottom two rows).

Figure S1. Graph of Smaller Sooner Choice by Age, Delay in Days, and Discount Rate.



Per the suggestion of an anonymous reviewer, we also examined a mixed effects model that nested delay length (in days 1 – 3650 days) inside delay length (labels days, weeks, months, and years) and took into account discount rates. This analysis essentially tells the same story as above: the change in the age trajectory appears in the for larger *k*-values (0.05, 0.10).

As can be seen in Table S6, most of the effects reported in the main text remain when controlling for the delay length label: main effect of age and the interaction between age and delay in days. The main effect of delay in days is no longer significant, but this may be due to adding *k*-values (discount rate) to the analysis, which explain a large amount of the variance (Figure S1).

Table S6 Mixed effects model

	Choice			
Predictors	*Std. Beta*	*Std. 95% CI*	*p*	*std. p*
(Intercept)	1.351 ***	1.191 – 1.533	**<0.001**	**<0.001**
Age	0.765 ***	0.729 – 0.802	**0.004**	**<0.001**
Discount Rate	0.451 ***	0.429 – 0.473	**<0.001**	**<0.001**
Delay in days	1.000	1.000 – 1.000	**0.019**	0.803
Age * Discount Rate	0.897 ***	0.854 – 0.943	**<0.001**	**<0.001**
Age * Delay in Days	1.000 ***	1.000 – 1.000	0.353	**<0.001**
Discount Rate * Delay in Days	1.000 ***	1.000 – 1.000	**<0.001**	**<0.001**
(Age * Discount Rate) * Delay in Days	1.000 *	1.000 – 1.000	**0.012**	**0.014**
Random Effects				
σ^2	3.29			
τ_{00} delay_unit:delay_n_days	0.03			
ICC	0.01			
N delay_unit	4			
N delay_n_days	9			
Observations	10368			
Marginal R^2 / Conditional R^2	0.160 / 0.168			

* *p<0.05* ** *p<0.01* *** *p<0.001*

References

Carstensen, Laura L., & Lang, F. R. (1996). *Future Time Perspective Scale*.

Lewis, N. A., & Oyserman, D. (2015). When Does the Future Begin? Time Metrics Matter, Connecting Present and Future Selves. *Psychological Science*, *26*(6), 816–825. https://doi.org/10.1177/0956797615572231

Rung, J. M., & Madden, G. J. (2018). Experimental reductions of delay discounting and impulsive choice: A systematic review and meta-analysis. *Journal of Experimental Psychology: General*, *147*(9), 1349–1381. https://doi.org/10.1037/xge0000462