Overview of the Delay Discounting Task (Now or Later)

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Table of Contents:

Background & Scientific Purpose

Individuals often have to make difficult decisions between immediate versus future benefits. The value of future benefits depends, however, on how far into the future those benefits occur. Delay discounting (or temporal discounting) refers to the tendency of people to perceive a reward as less valuable the further in the future it occurs. For example, given the choice between receiving $100 today or $120 in a year, many people would choose the $100 today, even though waiting would yield a greater reward.

The TestMyBrain Adaptive Delay Discounting task (Germine et al., 2022; Stern et al., 2024) measures temporal discounting by requiring participants to choose between two hypothetical monetary rewards on each trial: a smaller immediate reward or a larger future reward received after a delay. The test is an adaptive measure of decision making and temporal discounting (Levitt, 1971; Mazur, 1987; Myerson & Green, 1995; Yoon & Higgins, 2008) designed for remote, unsupervised administration. The delay discounting paradigm has previously been used to explore how temporal discounting relates to human behavior in many contexts, including eating disorders (Stern et al., 2024), drug use (Reynolds, 2006), gambling (Reynolds, 2006), and ADHD (Barley et al., 2001).

Methodology

On each test trial, participants choose between two hypothetical monetary rewards: one delivered immediately, the other delivered in the future. The immediate reward varies, while the future reward is always $1000, with varying delays that represent how far into the future the money would be received. The immediate reward is adjusted after every choice by a staircase procedure designed to home in on the participant's indifference point at each delay time (i.e. the immediate value that is equivalent to receiving $1000 after the given delay period). It is assumed that the value of the delayed $1000 reward is discounted in time according to a hyperbolic model (Mazur, 1987; Myerson & Green, 1995). Using the model, the discounting factor *k* is computed separately for each delay time and then averaged. The natural log of this mean discounting factor, lnk, is recommended as the primary outcome measure of the test. The larger the value of lnk, the greater the participant's temporal discounting – that is, the more they will tend to choose smaller immediate rewards over larger future rewards.

See Figure 1 for an overview of the test's structure. Participants read brief instructions before beginning the task (Figure 2). There are no practice trials for this test. In the brief version of the test included in *Exploring the Mind*, there are four delay periods: two weeks, one month, one year, and ten years.[1]

For each delay period, the participant completes a block of six consecutive trials. On the first of these six trials, the participant chooses between receiving $500 now (immediate reward), or $1000 after the delay period (future reward). For each successive trial of the delay period block, the immediate reward changes depending on previous responses to the delay period, while the future reward remains constant at $1000. The "change amount" for trials 2-6 is calculated as 500/(2^(count-1)), where "count" is the trial count for the current delay period [2-6]. When a participant selects the immediate reward on a trial, the next trial's immediate reward is set to the current immediate reward minus the change amount (e.g., if a participant selects the $500 immediate reward on a delay period's first trial, the immediate reward would be $250 for the delay period's second trial). When a participant instead selects the delayed reward on a trial, the next trial's immediate reward is set to the current immediate reward plus the change amount (e.g., if a participant selects the delayed $1000 reward on a delay period's first trial, the immediate reward would be $750 for the delay period's second trial).

In addition to completing six trials for each delay period, participants complete four *catch* trials. On each of these trials, which are included as an attention check, there is a clearly better reward option (e.g., $5 now, or $1000 in five minutes).[2]

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[1] In the standard version of the test (Stern et al., 2024), there are an additional three delay periods: six months, three years, and five years.

[2] The four catch trials use the following four pairs of response options: (1) $5 now, or $1000 in five minutes, (2) $2000 now, or $1000 in one month, (3) $1000 now, or $1000 in one year, (4) no money now, or $1000 in ten years.The four catch trials occur before the first delay period, then after each of the second, third, and fourth delay periods.

Participants have 30 seconds to make a response to each trial, after which a message appears warning the participant to respond more quickly; following the timeout message, the trial is repeated (see Figure 3 for an example trial). Participants' progress is visible throughout the test as a message displaying the current trial number and the total number of trials. Participants can respond to each trial using either a mouse click, touch input, or by pressing the "a" or "b" keyboard buttons.

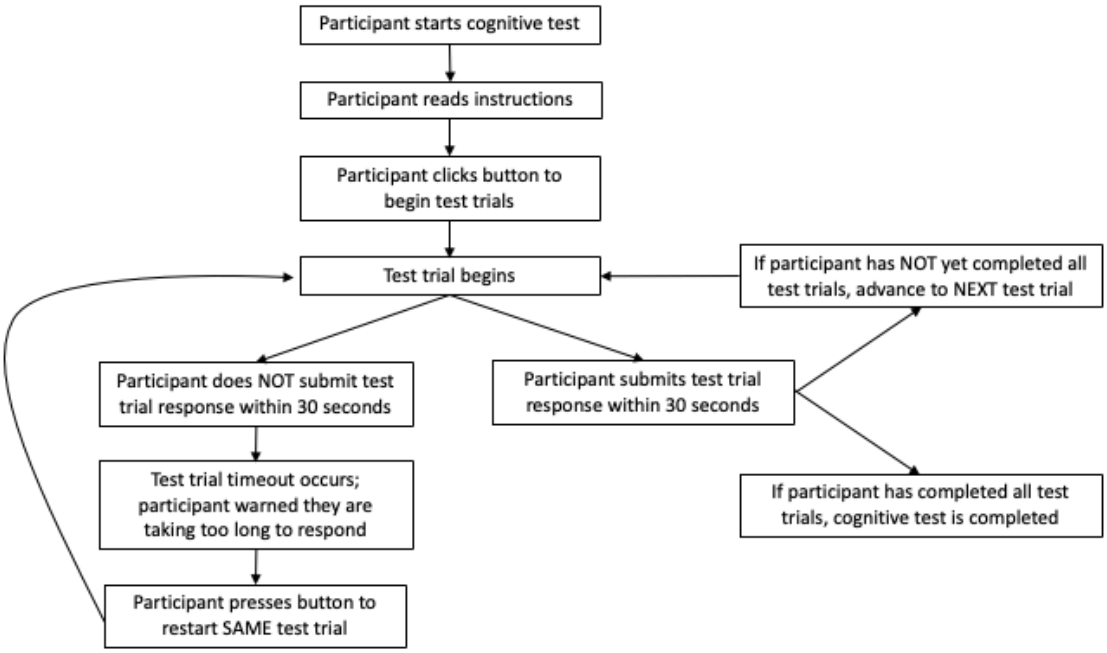

Figure 1: Overview of the structure of TestMyBrain Adaptive Delay Discounting

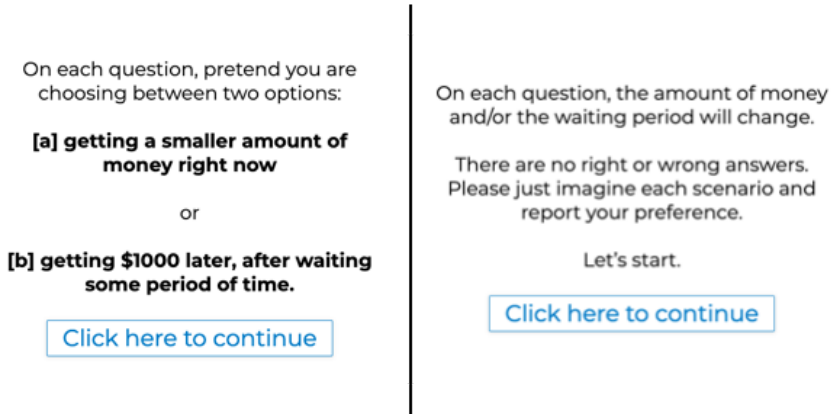

Figure 2: Instructions for TestMyBrain Adaptive Delay Discounting

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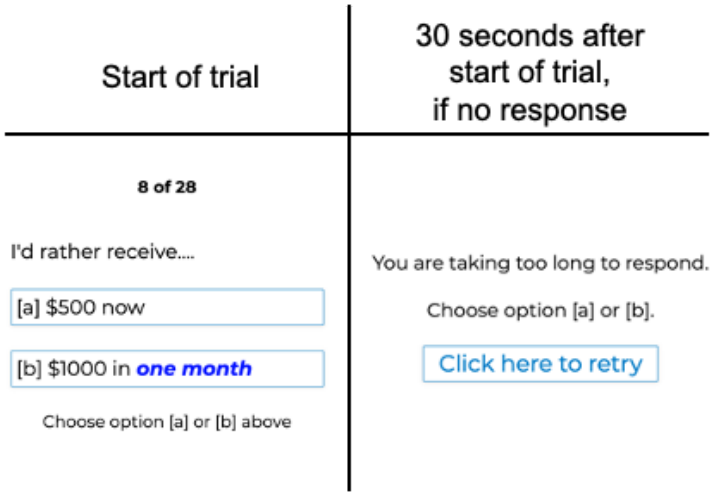

Figure 3: Example TestMyBrain Adaptive Delay Discounting trial

Data & Analysis Guidelines

Data

As described in the *Introduction to Cognitive Testing Data in the All of Us Research Program* Support Hub Article, there are three main categories of data available for cognitive tests: (1) trial-level data, (2) summary scores, and (3) metadata. Please see the Exploring the Mind Data Dictionary for a description of the trial-level data (trial_data), summary score (outcomes), and metadata (metadata) variables for this test (Delay Discounting).

Suggested Outcomes

The test's suggested primary outcome is *lnk*: the natural log of the average of the final discounting factors computed for each delay time. The larger this value, the greater the participant's temporal discounting (i.e., the more the participant values a smaller reward immediately over a larger reward in the future). The lower this value, the less the participant's temporal discounting (i.e., the more the participant values a larger reward in the future over a smaller reward immediately).

Outcome Type	Outcome Name	Description
Primary	lnk	The natural log of the average of the final discounting factors computed for each delay time. The larger this value, the greater the participant's temporal discounting.

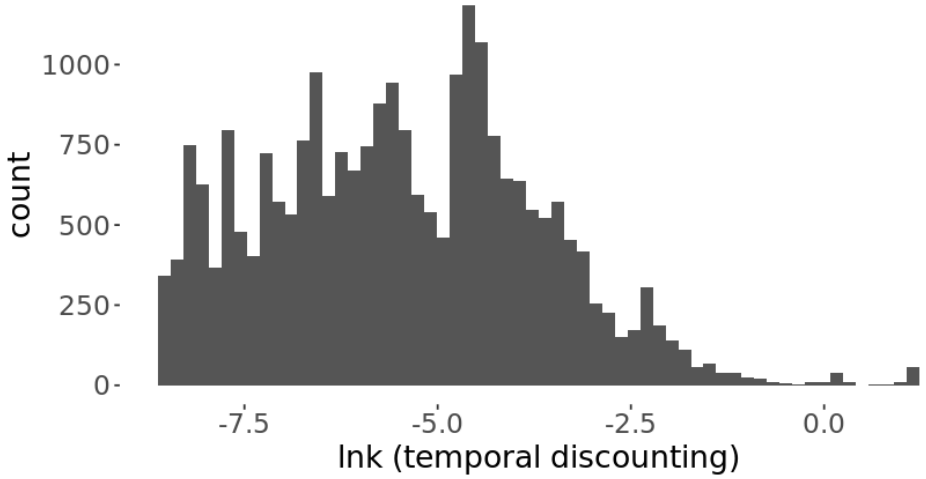

Figure 4: Histogram of primary outcome metric, lnk (temporal discounting factor), for all participants in the Curated Data Repository (CDR) v8 off-cycle release (N= 24,824).

Quality Control Guidelines

The following guidelines are provided for the purpose of flagging extreme deviations in performance from what is typically seen in participants performing the task in a valid manner. Researchers must use their own judgment when determining whether flagged participants should be excluded from analyses. Researchers may also consider implementing their own quality control criteria separately from these recommendations. For more details about quality control criteria, please see Introduction to Cognitive Testing Data in the All of Us Research Program.

Quality control variables for this test are only provided in full-test summary data - there are no trial-level quality control variables for this test. The table below summarizes the quality control variables available for this test.

Flag Type	Variable Name	Description
Full-test	flag_medianRT	Has a value of 1 if the participant has a median reaction time under 500 ms (medianRT < 500), and a value of 0 otherwise. A median reaction time under 500 ms is implausibly fast for this task and suggests the participant was responding carelessly.
	flag_catchTrials	Has a value of 1 when participants answer fewer than 75% of catch trials correctly (catch_score < .75), and a value of 0 otherwise. Answering fewer than 75% of catch

		trials correctly suggests that the participant may have not been reading the response options carefully.

Delay Discounting Task (N= 24,824)[3]		
	Yes	**No**
Catch Trial Flags	1.7%	98.3%
Median RT Flags	<1%[4]	>99%
Any Flags	1.7%	98.3%

Table 1: Percentage of participants with quality control flags in the Exploring the Mind CDR v8 off-cycle release.

Calculating Test Reliability

To calculate the reliability of Adaptive Delay Discounting performance differences between participants in a given sample, we recommend calculating Cronbach's alpha (Cronbach, 1951; Tavakol & Dennick, 2011) using the final lnk estimate from each of the four individual delay periods of each participant. Cronbach's alpha for the CDR v8 off-cycle release data for the Delayed Discounting task was 0.84 across the four delay periods. This result shows a high level of reliability. Figure 5 shows the correlation of lnk values computed separately for each delay period.[5]

[3]This count is defined as the total number of unique participants who completed the task.
[4]Due to the data dissemination policy, counts of less than 20 participants cannot be shared publicly. Users can view exact counts in the corresponding featured workspace after logging into their Researcher Workbench account.
[5]Cronbach's alpha, a metric of the test's overall reliability, is equivalent to applying the Spearman Brown prediction formula to the average of these correlation values (r = .57) to account for the fact that each delay period is only 1/4 of the entire test: (n*r) / ((n-1)*r + 1) = (4*.57)/(3*.57 + 1) = .84

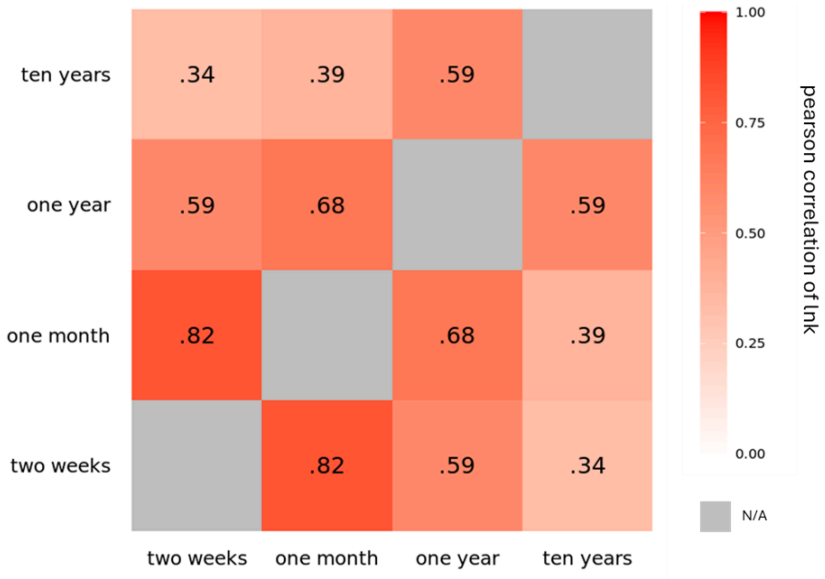

Figure 5: Correlation of lnk values computed separately for each delay period in the CDR v8 off-cycle data.

Correlates of Interest

Prior data collection has found associations between the following demographic variables and performance (lnk) on TestMyBrain Adaptive Delay Discounting. Therefore, researchers may consider including the following variables as covariates in analyses.

1. *financial circumstances*: although not published, prior data collection on TestMyBrain.org has found that financial circumstances (e.g., how much the participant needs money currently) are related to scores on this test. Therefore, researchers may consider using variables such as income level as covariates in analyses.
2. *education*: greater educational attainment is associated with less temporal discounting.

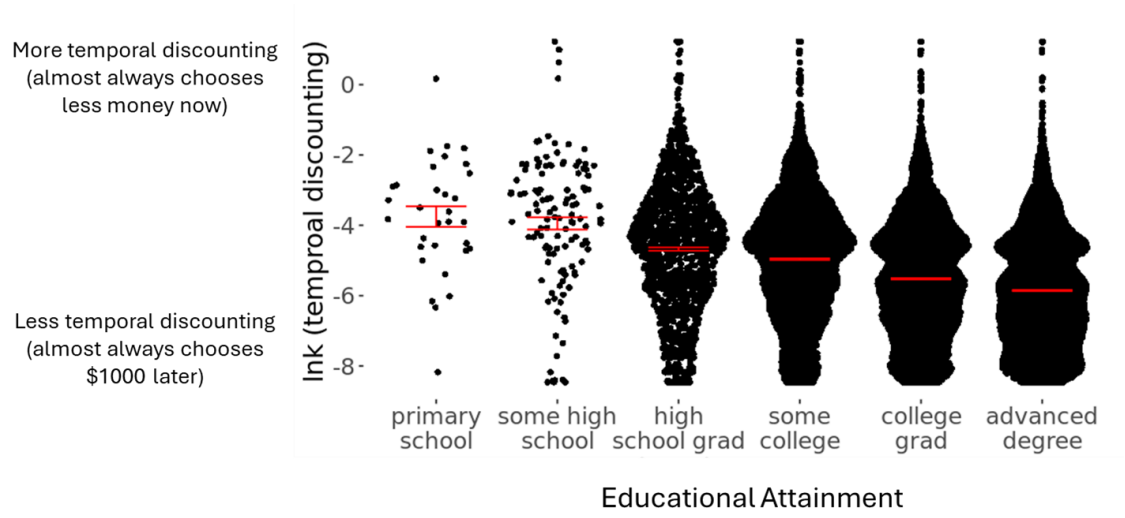

Figure 6: Temporal discounting by educational attainment in the CDR v8 off-cycle data. Red lines represent mean temporal discounting for each level of educational attainment. Black dots represent individual participants, and the width of the distributions represent the relative density of participants at each magnitude of temporal discounting.[6]

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[6] Participants were excluded from this plot if they did not report their educational attainment or reported that they never attended school.

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