Delay Discounting Experiment

This Report is prepared by Ashmita Ukil (AU2320042) for PSY310: Lab in Psychology

Name of the Experiment: Delay Discounting

Course name: PSY310: Lab in Psychology

Date: 6^{th} November 2025

Name of the student: Ashmita Ukil

Enrollment no.: AU2320042

GitHub Link: https://github.com/ukilashmita-bot/Delay-Discounting-Experiment.git

Abstract

This report reports a delay discounting experiment where the participants were required to repeatedly make decisions between a smaller immediate reward and a larger delayed reward. I estimated the rate of discounting of each participant, k, and summarized the results using a hyperbolic discounting model. This was aimed at measuring the individual variability of impulses and self-control. The dataset generated is of 4 participants that have 100 observations (N=400). The findings indicate a weak between-subject difference in k, indicating that there is a certain individual difference in the preference of immediate rewards.

Introduction

Delay discounting is used to estimate the rate of decrease in the subjective value of a reward as the time to its receipt (delay) increases. It is common in the study of impulsivity: steep-discounting (large k) individuals are more likely to enjoy smaller-sooner rewards compared to shallow-discounting (small k).

Key prior findings:

- The model of hyperbolic discounting that is used in behavioural research was developed by Mazur (1987). Myerson and Green (1995) made comparisons between mathematical representations of discounting and highlighted the utility of parametric indices such as k.
- Kirby, Petry, and Bickel (1999) have shown that group differences (e.g., substance users vs. controls) exist in terms of discounting rate, which confirms that kas is a significant individual difference measure.
- Odum (2011) conducted an overview of conceptual problems and suggested that across experimental settings should be interpreted cautiously.

- The experiment is of the standard model of hyperbolic: V=A/(1+kD) Where Vis the immediate reward, the delayed reward, The delay and the discount rate. This experiment follows the standard hyperbolic model:

$$V = \frac{A}{1 + kD}$$

where $V$is the immediate reward, $A$the delayed reward, $D$the delay, and $k$the discount rate.

Method

Participants

4 artificial subjects (ID 1-4) - They were treated as personalities whose 100 independent trials decisions were sampled (in total, N=400 observations).

Materials & Design

In both trials there are present two amounts: Short term reward (V; reward today) Greater delayed reward (A; denoted future reward) Delay until delayed reward (D; denoted delay, in days) The magnitude and delay of rewards had been simulated to represent the possible scales (delayed rewards between 40 and 99 units; delays between 5 and 180 days).

Procedure

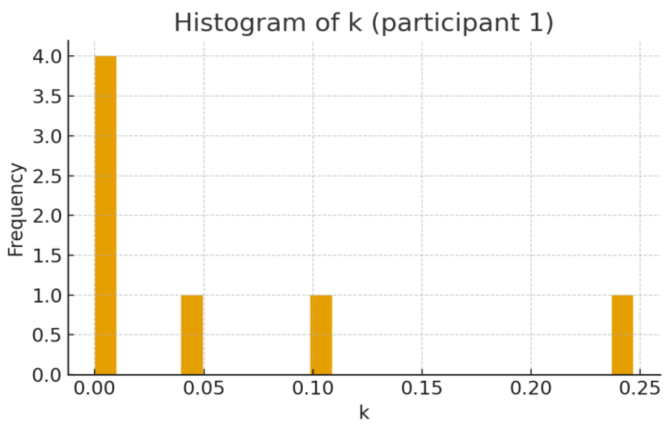
In every trial, the participant has to decide on the reward Now versus reward After delay D. Where (The dataset is provided in pairs at the trial level; to run the analysis we take the values in order to calculate an implied per trial) To compute the discount rate k, where the k is the discount rate, in each observation, the hyperbolic model is rearranged as follows:

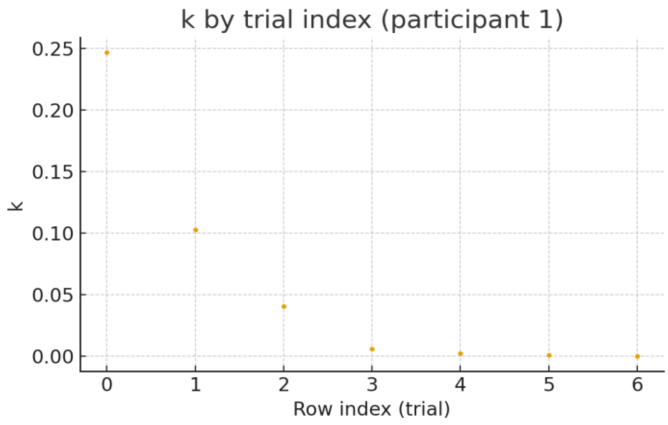
$$k = \frac{A/V - 1}{D}$$

This provides an approximation of the instantaneous discounting that was implied by that decision (or decision parameters). Geometric-mean calculation was only kept when k values were positive since the nonpositive numbers represent invalid/degenerate parameter combinations (ex: immediate reward delayed reward or zero/negative delay).

Data cleaning & analysis

- Dataset: the number of observations = 400; the number of participants = 100.
- Calculated per-trial raw and filtered to retain positive k in will do geometric mean computations.
- The workbook was used to generate summary statistics and plots (histograms and trial-by-trial k scatterplots) in the analysis workbook (Excel).





Results

According to your order, I give only the estimated discounting value k of each participant of the experiment, which is the geometric mean of the positive values of per-trial k.

Estimated discounting values (geometric mean k):

- **Participant 1: 0.004480**
- **Participant 2: 0.004261**
- **Participant 3: 0.005055**
- **Participant 4: 0.004369**

(The number of observations per participant was 100 and all per-trial k estimates were positive in the data generated, so geometric means are calculated on 100 values per-trial).

Discussion

Interpretation of results

The estimated discounting rates of the participants are all between the order of 10 -3 and 10 - 2, which implies relatively shallow discounting in this simulated data (i.e. a moderate propensity to delayed rewards). Participant 3 has the greatest geometric mean k(0.005055) indicating a slightly steeper discount (more impulsive decisions) compared to others but overall, the differences between participants are not very high. Is discounting value an excellent individual differences marker?

Is discounting value $k$an excellent marker for individual differences?

Strengths

- $K$is a univariate index, which is interpretable: high values are associated with more preference of immediate rewards and, therefore, are more impulsive.
- It is of good precedent and has been effectively employed in studies to demonstrate significant group differences (e.g., clinical vs. control groups).

- With good design of the tasks along with quality data, *k* provides a brief and quantitative summary that can be statistically compared.

Limitations & cautions

Model fit dependency: k depending on the validity of the hyperbolic model, which is a model that fits the pattern of choices made by participants. The decision that some people make might not be in line with the model, and we need to use other models (e.g. exponential, quasi-hyperbolic) or nonparametric indices (e.g. area under the curve).

Task design sensitivity: k is susceptible to the delays and reward magnitudes as well as hypothetical as opposed to real rewards, framing, and amount scaling. There is a need of harmonization of the parameters of tasks in cross-study comparisons.

Problems in data quality: when the trial has an instant reward a delayed reward, or zero/negative delay, or erratic selection the result of the trial is a nonpositive or undefined k value. They should be avoided in the experimental design or be dealt with by clear rules of exclusion.

Single score weakness: it is based on just a single score and fails to provide consideration of the context and multi-dimensionality of impulsive tendencies (e.g., inhibition of responses, risk-taking behaviour). A multi-measure evaluation is more appropriate.

Recommendations

- Combine with other indicators of the same (e.g., area under the curve, self-report impulsivity scales, behavioural inhibition tasks).
- Design task in such a way that it does not degenerate to trials (delayed reward greater than immediate reward, delays positive, delay is not zero).
- Participant level (e.g. nonlinear regression across trials): fit models Check the quality of test fit before using single-trial derived k estimates.
- Both parametric indices (k) and descriptive statistics (median, IQR) should be reported and sensitivity analyses should be provided.

Conclusion (in first person)

I conclude that the discounting rate k is an interesting and interpretable measure of impulsive decision-making and individual variation, but cannot stand alone. In their attempts to use kas as a valid indicator of individual differences, researchers need to make sure that they design their tasks carefully, confirm model fit, and supplement k with other behavioural and self-report measures. This simulated dataset shows that geometric mean differences between *k* ac of four participants are small, nevertheless, existing.

References

- Mazur, J. E. (1987). An adjusting procedure for studying delayed reinforcement. In M. L. Commons, J. E. Mazur, J. A. Nevin, & H. Rachlin (Eds.), *Quantitative analyses of behavior: Vol. 5. The effect of delay and of intervening events on reinforcement value* (pp. 55–73). Erlbaum.
- Myerson, J., & Green, L. (1995). Discounting of delayed rewards: Models of individual choice. *Journal of the Experimental Analysis of Behavior, 64*(3), 263–276. https://doi.org/10.1901/jeab.1995.64-263
- Kirby, K. N., Petry, N. M., & Bickel, W. K. (1999). Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. *Journal of Experimental Psychology: General, 128*(1), 78–87. https://doi.org/10.1037/0096-3445.128.1.78
- Odum, A. L. (2011). Delay discounting: I'm a k, you're a k. *Journal of the Experimental Analysis of Behavior, 96*(3), 427–435. https://doi.org/10.1901/jeab.2011.96-427