Attentional Choice Biases in Losses Involve Range Normalization and Look Like Choices Between Gains

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# Abstract

Simple choices between positively-valued options are common in our daily lives and are susceptible to robust attentional choice biases. However, we also encounter choices between negatively-valued options. We find that in choices between losses, the same attentional choice biases from the gain domain still remain. This is inexplicable with attentional discounting, unless the value comparison process involves some form of range normalization. We also find causal evidence that attentional manipulations affect value-based decisions.

# Introduction

Motivation > Literature Review > Research Question > Short Description of Experiments > Hypotheses > Preview the Results

[[fig\_task\_dots] [fig\_task\_numeric] [fig\_task\_food]]

# Results

## Basic Psychometrics

[[fig\_psychometric\_gl] [fig\_rt\_gl] [fig\_nfix\_gl]]

## Fixation Process

[[fig\_firstbest\_gl] [fig\_fixdurtype\_gl] [fig\_netfix\_gl]] \*I want to cut out first and middle fixation durations wrt difficulty\*

## Computational Model

We use the Attentional Drift-Diffusion-Model (aDDM) to analyze choices and response times in the data. The model initializes a Relative Decision Variable, , at , called the starting point bias. As the subject observes the stimuli, they gather and integrate evidence in favor of one option or the other until this evidence variable hits a decision boundary, fixed at :

where is i.i.d. white Gaussian noise that captures noise in the decision process. If the subject is looking left at time , then evidence at time , , equals . If the subject is looking right, then . is the expected value of the left and right lotteries, respectively. is the drift rate parameter, reflecting the amount of evidence the subject accumulates per discrete time-step (e.g. 10 ms). is the attentional bias parameter, reflecting how subjects over-weight the value of the currently fixated option. The aDDM nests the standard DDM (Ratcliff et al., 2016) when , implying no attentional bias. Note that the aDDM here assumes the fixation process is independent of the current state of evidence, though recent work has incorporated endogenous fixation patterns (Gluth et al., 2020).

Because , when , the steam of is biased towards the fixated option (Fig. 1a), and thus the aDDM would predict that the agent is more likely to choose the more fixated option and last fixated option (Fig. 1c). However, when , the steam of is instead biased towards the nonfixated option (see Fig. 1b), so the aDDM would predict a flip in these attentional choice biases (see Fig. 1d).

a b

Fig. . aDDM examples. (a) An illustration of how the Attentional Drift-Diffusion-Model (aDDM) makes decisions in a sample trial involving gains. (b) A similar illustration, but in a sample trial involving losses. Colored vertical bands denote fixation locations.

[[fig\_addm\_example\_gain] [fig\_addm\_example\_loss] [fig\_addm\_nfb] [fig\_addm\_lfb]]

## Choice Biases (Study 1, 2, and 3)

[[fig\_nfb] [fig\_lfb]]

## Range Normalized aDDM (RNaDDM)

Brief descriptions of the different models we tried. Most of the details should go into supplementary.

[tab\_model\_comparison]

[tab\_addm\_groupestimates]

[[fig\_rnaddm\_individualestimates] [fig\_rnaddm\_simulations]]

## Attentional Manipulations

[[fig\_psychometric\_fixcross] [fig\_netfix\_fixcross] [fig\_lfb\_fixcross]]

# Methods

## Participants

To obtain high quality data, we implemented a participant filter at the data collection stage. Immediately after data collection, we deleted participants who failed any of the following criteria: (a) (b).

A total of 160 participants were recruited from Caltech and the surrounding community using flyers. 91 participants were recruited to the dot study. Of these, 19 were excluded for failing our participant filter, leaving 72 participants in the dot study (age: mean = 25 years, range = 18-41; gender: 26 male, 45 female, 1 non-binary; ethnicity: 27 Asian, 3 Black, 10 Hispanic, 3 Middle Eastern, 0 Native American, 28 White, 1 Abstain). 69 participants were recruited to the numeric study. Of these, the first 6 were excluded due to a change in the instruction phase of the experiment and 13 were excluded for failing the participant filter, leaving 50 participants in the numeric study (age: mean = 27.68 years, range = 18-55; gender: 13 male, 34 female, 3 non-binary; ethnicity: 17 Asian, 5 Black, 10 Hispanic, 1 Middle Eastern, 1 Native American, 16 White, 0 Abstain).

We prescreened participants against requiring glasses for vision correction that might interfere with eye tracking. Participants were paid a $40 show-up fee, and gains (losses) earned from the experiment were added (deducted) to this amount. All participants gave informed consent, and all experiments were approved by Caltech’s Institutional Review Board.

## Task

### Study 1: Dots

### Study 2: Numeric

## Eye-Tracking

We recorded subjects' fixation patterns at 500 Hz using an EyeLink 100. Subjects sat about 60 cm away from a 1920 by 1080 pixel monitor. Lottery circles had a radius of 300 pixels, [numeric lottery dimensions]. Fixations within the ROI of the left lottery were recorded as "left", while fixations to the right lottery were recorded as "right". Occasionally, due to blinks or eye-tracker noise, fixation patterns exhibit transient "blank" recordings between two fixations to the same ROI (e.g. left-blank-left). We recode these as a single fixation to the same ROI (e.g. left-left-left). Transient "blank" recordings between two fixations to different ROI (e.g. left-blank-right) are recorded as saccades between fixations. We dropped an average of [txt\_average\_missing\_trials\_dots] in the dots study, [txt\_average\_missing\_trials\_numeric] in the numeric study.

## Inference Strategy

## Model Fitting

[txt\_addm\_timestep]

[txt\_addm\_statestep]

## Simulations

[txt\_n\_simulated\_datasets]

## Regressions

[txt\_regression\_burnin]

[txt\_regression\_samples]

# Discussion

# Significance Statement