Title

Analyzing the Impact of Choice Complexity on Personal Risk Choices

Description

Individuals make numerous decisions on a daily basis. Many of these decisions are based on a high amount of information that must be processed in order to make a good decision. Due to imprecisions in the processing of this information, decisions can be noisy and can fail to maximize expected utility. Here, we want to examine how the complexity of the choice environment as the amount of information that need to be processed affects decision making under risk. Based on previous research, our general expectation is that everything else equal people tend to avoid complex options and prefer simpler ones.

In this experiment, we will apply binary lottery choice problems with simple and complex lotteries. Both lotteries consist of two outcomes that can occur with varying probabilities. Complexity is manipulated by presenting lotteries as compound, meaning that their final outcome realizations are based on two stochastic nodes. We will examine choice problems with only simple lotteries (simple versus simple), only complex lotteries (complex versus complex) and mixed (simple versus complex). We will analyze the choice patterns and the response times (RT) in each condition. Furthermore, we will develop models in the framework of drift diffusion model to analyze the experimental data. Within the framework of the diffusion model, we can elucidate people's cognitive processes when faced with options of different complexity.

Study Information

Hypotheses

1 Behavioral Hypothesis:

Condition Simple versus Complex Options

In the context of decision-making under risk, individuals exhibit complexity aversion. Complexity aversion means when presented with two alternatives, one simple and one complex, of comparable value, individuals will choose the simpler option more often.

1.2 Condition Simple versus Simple and Complex versus Complex

In simple versus simple or complex-complex choice situations, we expect faster response times in simple versus simple compared to complex versus complex because simpler options need less accumulation time.

In addition, we expect choice consistency to be higher in simple versus simple than complex versus complex because it is easier for participants to accumulate and process the information

when it is simple. We approximate choice consistency behaviorally with the effect of the EV-Difference on choice proportions.

2 Cognitive Mechanism Hypotheses to Explain Complexity Aversion:

2.1 Complexity aversion is mainly driven by a pre-valuation bias, whereby individuals exhibit a preliminary disposition against complex options prior to the accumulation of substantial information.

2.2 Complexity aversion is mainly driven by a discounting effect that occurs during information accumulation. This effect results in the perceived value of complex options being subjectively "discounted".

2.3 Complexity aversion is mainly driven by the subjective representation of outcome probabilities. Participants have a stronger curvature for decisions weights for complex than for simple options, leading to decisions weights being closer to 50 percent in case of complex lotteries. This is the case because for complex lotteries it is harder for participants to accumulate the probability information.

3 Cognitive Mechanism Hypotheses to Explain Differences in Simple versus Simple and Complex versus Complex conditions:

3.1 Participants differ in the evidence accumulation between simple versus simple and complex versus complex conditions. This would show in a difference in the choice consistency parameter θ.

3.2 Participants differ in the subjective representation of outcome probabilities between simple versus simple and complex versus complex conditions. This would show in a difference in the parameter $\Delta\gamma$.

3.3 Participants differ in the threshold between simple versus simple and complex versus complex. This would show in a difference in the threshold parameter alpha.

4 Additional Correlation Hypotheses:

4.1 Complexity aversion, that is the percentage of complex choices in the condition simple versus complex, is positively correlated with cognitive ability. This is the case because participants with high cognitive ability are less affected by the additional information processing difficulty in the complex options.

4.2 Individual differences in the latent choice consistency parameter θ between simple versus simple and complex versus complex condition are negatively correlated with cognitive abilities. This is the case because participants with high cognitive abilities do not show strong differences in choice consistency due to the complexity manipulation.

4.3 Individual differences in the latent choice consistency parameter θ between simple versus simple and complex versus complex conditions is negatively correlated with complexity aversion, that is the percentage of complex choices in the condition simple versus complex. This correlation would be adaptive, in that participants which are strongest negatively affected by complexity, also choose complex options less often.

Design Plan

Study type

Experiment - A researcher randomly assigns treatments to study subjects, this includes field or lab experiments. This is also known as an intervention experiment and includes randomized controlled trials.

Blinding

Personnel who interact directly with the study subjects (either human or non-human subjects) will not be aware of the assigned treatments. (Commonly known as "double blind")

Study design

Within-subject design. All Participants will have two main experiment blocks, in both blocks they have to make decisions between two lottery options. There are two types of lotteries – simple and complex. The simple lotteries consist of two outcomes with corresponding probabilities. The complex lotteries also consist of two outcomes, but will involve two steps and require participants to perform calculations to determine the final outcomes and probabilities. All pairs of lottery options will have different level of characteristics, which contains EV difference (-20, -10, 0, 10, 20), SD difference (15, 10, 5) and skewness difference (no skewness, right skewed versus left skewed and left skewed versus right skewed).

Before the main block, participants are required to successfully answer three comprehension questions. This is to ensure their understanding of the experimental design. When participants select an incorrect response, they will be prompted to reattempt the question until the correct choice is selected. Each question presents four options, among which only one is correct.

In one main block, the two lotteries are always in same kind, namely simple versus simple option or complex versus complex option. In the other block there will be lotteries in different kind, namely simple option versus complex option. For all trials, the two lottery options will always be presented simultaneously and the order will be randomized.

Participants have 35 seconds to make their decisions in each trial. Participants will receive a message when 30 seconds have elapsed, informing them that they have 5 seconds remaining to make their decision. If participants do not respond within 35 seconds, they must click a button to proceed to the next trial. However, decisions made after 30 seconds will not be considered in the data analysis because the warning could change the assumed cognitive process; they will only be used to determine the bonus payment. We have set the valid response time limit at 30 seconds, based on results from our pilot study where the maximal median reaction time in each condition was 15 seconds. We doubled this time, believing it provides sufficient time for participants to make decisions without feeling time pressure.

After the main blocks, participants will complete two cognitive ability tasks. Namely the Berlin Numeracy Test consisting of four questions about probabilities and numbers and a shortened Matrix Task consisting of six items to measure fluid intelligence.

Randomization

The following structure will be fully randomized:

- Order of two main blocks

- Order of trials within each block

- Order of two lotteries within each trial.

Sampling Plan

Existing Data

Registration prior to creation of data

Data collection procedures

This research will involve recruiting participants through advertising on Prolific Academic. We will only recruit participants with good records, such as a 95% approval rate. For the online studies, participants who successfully complete the experiment will be compensated at a rate of 10 pounds per hour, in addition to receiving a monetary bonus. At the end of the experiment, a choice problem will be randomly selected and performed based on the participant's chosen option. The outcome of this selection will determine the bonus payment, which approximately 2 pounds on average. Consequently, participants can expect to receive an average total payment of 12 pounds per hour, with a minimum payment of 10 pounds per hour guaranteed in the absence of a bonus.

Participants are allowed to participate in the study until the specified sample size is reached.

Sample size

Our target sample size is 125 participants. We will attempt to recruit up to 150, assuming an exclusion rate of up to 20%.

Sample size rationale

We aim for a sample size of 125 after participant exclusions. With 125 participants we have more than 99% power to find an effect at least 80% as strong as in Oberholzer et al. (2023) of complexity on average participant choice proportions against 50% in a two-sided one-sample t-test in choices with one simple and one complex option. At the same time, 125 participants would give us 80% power to find a correlation of at least 0.25 between behavioral measures in our main task or between behavioral measures in our main task and our measures of cognitive abilities.

We acknowledge the possibility of incomplete responses or the necessity to exclude participant data based on our exclusion criteria. To account for this, we plan to recruit 150 participants initially through Prolific.com. Recruitment will be stopped after 150 participants if the initial sample meet our required sample size. If, however, participant exclusion is higher than anticipated, we will resume recruitment in increments of 10 participants, continuing until we reach our necessary sample threshold.

Variables

Manipulated variables

• Gamble EV (one level) – 6-140

• Complexity (two levels) – simple (2 outcomes, direct probability) and complex (2 outcomes, indirect probability)

• Variance (SD - three levels) – low (5), medium (10), high (15)

• EV Difference (five levels) - 20, -10, 0, 10, 20

• Skewness (three levels) – left versus right, no, right versus left

Measured variables

Choice Task

- Choices

- Reaction time

- Number of correctly solved matrices and questions

At the end of the experiment:

- Comments

Overall:

- Duration of each element (reaction times)

Analysis Plan

Statistical models

1 Behavioral Analyses:

Hypothesis 1.1:

• One sample t test comparing the mean choice proportion of complex options against the 50% benchmark for trials in simple versus complex conditions.

Expected results: The choice proportion of complex option will be significantly lower than 50%.

Hypothesis 1.2:

• Two-sample *t* test comparing participant-level median response times in simple versus simple condition against complex versus complex condition.

We expect slower response times in simple versus simple condition than in complex versus complex condition.

• Two-sample *t* test comparing Coefficient of EV in a logistic regression on choice in simple versus simple condition against complex versus complex condition in a mixed-effects regression participant-level intercept and slope.

We expect higher Coefficient of EV in simple versus simple condition than in complex versus complex condition.

• Two-sample *t* test comparing percentage of risky choices in simple versus simple condition against complex versus complex condition.

We have no theoretical reasons to expect a significant difference when we assume that complexity might increase processing noise equally for risky and not the risky (in terms of variance) options.

General Modeling methods for Examining the Cognitive Mechanism Hypotheses

Hierarchical drift diffusion models will be fit to behavioral data using the rstan package for R (Stan Development Team, 2023).

Model parameters for all models include: t (non-decisional time), α (choice boundary), v (drift rate), θ (choice consistency parameter), β (risk sensitivity parameter). Some model specifications will have one or more of the additional parameters: z (starting point, 0 if neutral), η (complexity discounting), and γ (curvature of probability weighting function; separate for simple and complex).

We will look at 95% CI of each parameter. Based on the hypotheses, we will compare the performance of different models using LOOICs (Vehtari et al., 2017). The details of models remain under development.

2. Hypotheses simple versus complex

Hypothesis 2.1: There is a credible starting point bias towards simple options (95% HPDI excludes zero for z)

Hypothesis 2.2: There is a credible discounting of complex options (95% HPDI excludes zero for η)

Hypothesis 2.3: There is a credible difference between probability weighting of simple and complex options (95% HPDI excludes zero for $\Delta\gamma$)

3. Hypotheses simple versus simple and complex versus complex

Hypothesis 3.1: We implement a dummy parameter for the consistency parameter θ that codes whether a choice was made in simple versus simple or complex versus complex condition.

We assess whether the 95% HPDI excludes zero for a credible difference of $\Delta\theta$ across conditions. We expect credibly higher consistency for simple versus simple compared to complex versus complex.

Hypothesis 3.2: There is a credible difference between probability weighting of options in the simple versus simple against complex versus complex condition (95% HPDI excludes zero for $\Delta\gamma$)

Hypothesis 3.3: We implement a dummy for threshold α similar to above and assess the 95% HPDI of this parameter. We do not expect a significant difference.

4 Correlation Hypotheses

Hypothesis 4.1: Pearson correlation test between percentage of complex choices in the condition simple versus complex and averaged cognitive ability test scores

We expect positive correlation

Hypothesis 4.2: Pearson correlation test between Individual differences in the latent choice consistency parameter $\Delta\theta$ between simple versus simple and complex versus complex condition and averaged cognitive ability test scores

We expect negative correlation

Hypothesis 4.3: Pearson correlation test between Individual differences in the latent choice consistency parameter $\Delta\theta$ between simple versus simple and complex versus complex condition and the percentage of complex choices in the condition simple versus complex

We expect negative correlation

Inference criteria

As far as possible, we rely on Bayesian Statistics (95%-Credible Intervals).

Data exclusion

Exclusion:

Participants:

1. unsuccessful manipulation check (All participants must answer three comprehension questions before the main block. Those who require more than six attempts in total will be excluded, indicating an average of two attempts per question. If a participant selects all correct options on their first attempt for each question, their total number of attempts should be three.)

2. Other not allowed behaviours (e.g., restarting the experiment)

3. Participants for whom we remove more than 50% of trials (see criteria below) will be completely removed

Individual trials:

1. All trials that have a response time less than 1 second or more than 30 seconds

2. From the remaining trails we will exclude all trials with a response time greater than median + 3 SD or less than median – 3 SD, where the median is calculated individually for each participant and each condition (simple versus simple; complex versus complex; simple versus complex)

Missing data

The missing data in this study should be the response when participants do not make any choice within 35 seconds for each trial. In this case, all these trials will be excluded.

Exploratory analysis