Pre-Registration

Analyzing the Impact of Choice Complexity on Personal Risk Choices

Maohua Nie

Version 1, edited November 2, 2023

1 Study Information

1. Title (required) Analyzing the Impact of Choice Complexity on Personal Risk Choices

2. Authors (required) Maohua Nie, Dr. Sebastian Olschewski, Prof. Dr. Jörg Rieskamp

3. Description (optional)

Individuals make numerous decisions on a daily basis, but often lack the ability to make optimal choices due to the overwhelming amount of information they must process. As cognitive misers, people tend to avoid complex options and prefer simpler and more intuitive alternatives, even if they are not necessarily superior. Previous research has examined the complexity structure of options and has suggested that it can significantly influence individuals' risk choices. Among these studies, compound lotteries are often used as a manipulation of complexity.

However, it should be noted that most studies define complexity solely in terms of the number of alternatives or the number of features, and the predominant experimental design involves comparing individuals' preferences for choices with different numbers of potential outcomes. Nonetheless, complexity can also refer to the cognitive effort required to process information, even if the number of potential outcomes remains constant. In other words, options with higher complexity may demand more time and cognitive resources to explore their possible outcomes. Importantly, most of the research on complexity has focused on one type of complexity. In addition, cognitive models have hardly been used to explain people's risky choices.

To fill this research gap, our study will employ a series of tasks with different operatinalizations of complexity to examine whether individuals' risk choices are affected by differences in complexity resulting from variations in cognitive burden. We will utilize a series of binary decision problems, such as compound lotteries, to manipulate the complexity involved in calculating each outcome and its respective probability. Such design ensures that we can test whether different forms of complexity can have similar effects on people's risky decisions. Furthermore, We will try to develop models in the framework of drift diffusion model, which has not been used widely in prior studies, to analyze the experimental data. The diffusion model is a model of a cognitive process involving a simple two-choice decision, it assumes that the decisions are made in a noisy process, in which people accumulate information over time from a starting point toward one of two options and begin to respond when one of these boundaries is reached. The model is well suited for fast binary choices. Thus, within the framework of the diffusion model, we believe that our analysis of risky choices will be more reliable and robust, and will allow us to learn about people's cognitive paradigms when faced with options of different complexity.

4. Hypotheses

4.1 Behavioral Hypothesis:

4.1.1 Condition Simple vs. 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.

4.1.2 Condition Simple vs. Simple and Complex vs. Complex

In simple-simple or complex-complex choice situations, we expect faster response times in simple-simple compared to complex-complex because simpler options need less accumulation time.
In addition, we expect choice consistency to be higher in simple-simple than complex-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. Alternatively we can look at the choice proportions for the better option in the catch trials with first order-stochastic dominance.

4.1.3 Cognitive Mechanism Hypotheses to Explain Complexity Aversion:

First hypothesis: 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.

Second hypothesis: 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 reduced or "discounted".

Third hypothesis: 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 50-50 in case of complex lotteries. This is the case because for complex lotteries it is harder for participants to accumulate the probability information.

4.1.4 Cognitive Mechanism Hypotheses to Explain Differences in Simple-Simple vs Complex-Complex:

First hypothesis: Participants differ in the evidence accumulation between simple-simple and complex-complex. This would show in a difference in the choice consistency parameter θ.
Second hypothesis: Participants differ in the threshold between simple-simple and complex-complex. This would show in a difference in the threshold parameter a.

4.2 Additional Correlation Hypotheses:

Complexity aversion, that is the percentage of complex choices in the condition simple vs. 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.

Individual differences in the latent choice consistency parameter θ between simple-simple and complex-complex 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.

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

2 Design Plan

5. Study type (required)

Example: 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.

6. Blinding (required)

For studies that involve human subjects, they will not know the treatment group to which they have been assigned. 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")

7. Study design (required)

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. We will also include other manipulation of complexity in the following studies. 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 vs. left skewed and left skewed vs. right skewed)
In one main block, the two lotteries are always in same kind, namely simple option vs. simple option or complex vs. complex option. In the other block there will be lotteries in different kind, namely simple option vs. complex option or complex option vs. simple option. For all trials, the two lottery options will always be presented simultaneously.
After the main blocks, participants will also complete two cognitve ability tasks.

8. Randomization (optional)

The following structure will be fully randomised:
- Order of two main blocks
- Order of trials within each block
- Order of two lotteries within each block

3 Sampling Plan

9. Existing data (required)

Registration prior to creation of data

10. Data collection procedures (required)

This research will involve recruiting participants through advertising on Prolific.co. We will only recruit participants with good records, such as a 95% approval rate. Recruitment will commence once we receive ethic approval and finalize the experiment webpage.
For the online studies, participants who successfully complete the experiment will be compensated at a rate of $10 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 is expected to be approximately $5. Consequently, participants can expect to receive an average total payment of $15 per hour, with a minimum payment of $10 per hour guaranteed in the absence of a bonus. It is important to note that this total payment surpasses the minimum wage per hour for participants in the United States, which stands at $7.25 per hour and $8 for participants in Prolific.
Participants are allowed to participate in the study until the specified sample size is reached.

11. Sample size (required)

Our project sample should be around 125 participants for online studies. We will attempt to recruit up to 130, assuming that not all will complete the task correctly.

12. Sample size rationale (optional)

We aim for a sample size of 125 after participant exclusions. With 125 participants we have a 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 130 participants initially through Prolific.co. Recruitment will be stopped once 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.

4 Variables

13. Manipulated variables

- Gamble EV(one level) – 30-200
- 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 vs. right, no, right vs. left

14. Measured variables

Choice Task
- Choices
- Reaction time
- Manipulation Check: MCT about instructions)

Cognitive Ability Task
- Number of correctly solved matrices and questions

At the end of the experiment:
- Demographics (Age, Gender, education level)
- Comments

Overall:
- Duration of each element (reaction times)

5 Analysis Plan

15. Statistical models (required)

Behavioral Analyses:

Hypothesis 4.1.1:

- One sample t test comparing the mean choice proportion of complex options against the 50% benchmark for trials in simple vs. complex conditions.
  Expected results: The choice proportion of complex option will significantly different from 50%.

Hypothesis 4.1.2:

- Two-sample t test comparing response time in simple-simple versus complex-complex.
  We expect slower response times in complex-complex versus simple-simple.
- Two-sample t test comparing Coefficient of EV in a logistic regression on choice in simple-simple versus complex-complex.
- Two-sample t test comparing Coefficient percentage of superior choices in catch trials in simple-simple versus complex-complex.
  We expect higher consistency and more superior choices in simple-simple versus complex-complex.
- Two-sample t test comparing percentage of risky choices in simple-simple versus complex-complex.
  We expect no significant difference.

Modeling methods for Examining the Cognitive Mechanism Hypotheses (hypothesis 4.1.3)

Hierarchical drift diffusion models will be fit to behavioral data using the rstan package for R (Stan Development Team, 2023).
Model parameters include: t (non-decisional time), z (starting point, 0 if neutral), α (choice boundary), v (drift rate), θ (choice consistency parameter), δ (risk sensitivity parameter), β (discounting effect) and γ (curvature of probability weighting function).
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.

Hypothesis 4.1.4:

- paired-samples t test comparing the choice consistency parameter θ in individual level in simple vs simple against in complex vs complex condition.
  We expect significant difference.
- paired-samples t test comparing the threshold parameter α in individual level in simple vs simple against in complex vs complex condition.
  We expect significant difference.

16. Transformations (optional)

17. Inference criteria (optional)

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

18. Data exclusion

Exclusion:
Participants:
1. unsuccessful manipulation check (total attemps > 6)
2. Less than 6/8 accuracy in control trials
3. completing the experiment too fast (1/4 of mean time) or too slow (three times of mean time)
Other not allowed behaviours (e.g., restarting the experiment)

data points:
1. All trials that has reaction time in the range of 0%-2.5% and 97.5%-100% in each condition
2. All trials that has reaction time less than 1 second

19. Missing data (optional)

There will be no missing data.

20. Exploratory analysis (optional)

Additional Correlation Hypotheses on cognitive ability
Hypothesis 4.2

- correlation test between percentage of complex choices in the condition simple vs. complex and averaged cognitive ability test scores
  we expect positive correlation.
- correlation test between Individual differences in the latent choice consistency parameter θ between simple vs. simple and complex vs . complex condition and averaged cognitive ability test scores
  we expect negative correlation.
- correlation test between Individual differences in the latent choice consistency parameter θ between simple vs. simple and complex vs . complex condition and the percentage of complex choices in the condition simple vs. complex
  we expect negative correlation.

6 Other

21. Other