# Pre-analysis plan: Belief elicitation under ambiguity

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## 1 Introduction

Beliefs play a critical role in many economic, political, and life decisions. Hence, researchers have been interested in eliciting individuals' beliefs to better understand their decision-making processes. A fundamental challenge in experimental economics has been creating incentives for experimental participants to truthfully report their beliefs. In recent years, researchers have developed sophisticated methods to elicit the beliefs of experimental participants in an incentive-compatible manner (see Schotter and Trevino, 2014; Schlag et al., 2015; Trautmann and van de Kuilen, 2015; Charness et al., 2021, for reviews). One state-of-the-art method to elicit beliefs is the binarized scoring rule (BSR), which is incentive compatible even under non-neutral risk preferences (Hossain and Okui, 2013). To date, the discussion around the incentive compatibility of belief elicitation methods remains agnostic about the influence of ambiguity. This is surprising in light of the fact that experimenters are often interested in

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beliefs about ambiguous events. In this project, we investigate how reported beliefs under the BSR deviate from the implied objective probabilities for ambiguous and risky events, and how such deviations depend on the level of detail used to explain the BSR, the stake size, and participants' ambiguity preferences. Finally, we examine the extent to which reported beliefs deviate in line with theoretical predictions based on individuals' ambiguity preferences.

# 2 Experimental design

Our experiment consists of three individual parts. In Part A, we elicit participants' beliefs about ambiguous and risky events. In Part B and Part C, we elicit participants' ambiguity and risk preferences, respectively.

## 2.1 Part A: Belief elicitation

Part A consists of six rounds of an individual decision-making task. In each round, we present participants with an urn containing 10 balls of different colors. At the beginning of each round, participants receive information about the composition of the urn. The participants' task is to report a probabilistic belief pertaining to the color of the ball randomly drawn from the urn.

In a within-subjects design, we vary: (i) whether the proportion of balls of each color type is unknown (ambiguous) or known (risky), and (ii) the implied objective probability of the predicted event $p \in \{0.2, 0.5, 0.8\}$. In the first 3 rounds, we elicit participants' beliefs about the ambiguous events. In the next 3 rounds, we elicit participants' beliefs about the risky events. The order of the implied objective probabilities $p \in \{0.2, 0.5, 0.8\}$ will be independently randomized within each block of 3 rounds. After each belief report, we follow the procedure in Enke and Graeber (2023) and ask participants to indicate how certain they are that the optimal belief report, given the incentivization procedure, lies within a two-percentage-points interval around their belief report.

In a between-subjects design, we vary: (i) the level of detail used to explain

the BSR, and (ii) the stake size. Hence, we have a 2-by-2 between-subjects design with the following treatments:

- **Detailed High:** Participants receive *detailed instructions* on the BSR, and they have the opportunity to receive a *high* prize of *€15* under the BSR.
- **Detailed Low:** Participants receive *detailed instructions* on the BSR, and they have the opportunity to receive a *low* prize of *€1.50* under the BSR.
- **Simple High:** Participants receive *simple instructions* on the BSR, and they have the opportunity to receive a *high* prize of *€15* under the BSR.
- **Simple Low:** Participants receive *simple instructions* on the BSR, and they have the opportunity to receive a *low* prize of *€1.50* under the BSR.

## 2.2 Part B: Ambiguity preference elicitation

We adapt the method from l'Haridon et al. (2018) and Delavande et al. (2022) to elicit participants' incentivized ambiguity preferences.

## 2.3 Part C: Risk preference elicitation

We adapt the method from Tanaka et al. (2010) to elicit participants' incentivized risk preferences.

## 2.4 Questionnaire

At the end of the experiment, participants are asked to complete a questionnaire consisting of several sections. First, we adapt the method by Cavatorta and Schröder (2019) to elicit participants' unincentivized ambiguity preferences. Second, we use the method by Falk et al. (2023) to elicit participants' unincentivized risk preferences. Third, we elicit participants' unincentivized

beliefs about the exact urn composition (for ambiguous events), and the underlying motives behind their belief reports (for ambiguous events). Fourth, we elicit participants' motives behind belief reports that deviate from the implied objective probabilities (for risky events). Fifth, we ask participants to complete a quiz on the calculation of payoffs under the BSR, as well as the cognitive reflection test. Finally, we ask participants to report their level of understanding of the instructions, as well as various demographic variables.

### 2.5 Procedures

The experiments will be programmed using *oTree* (Chen et al., 2016). For each participant, one decision in the experiment is randomly chosen for payment. All randomizations used in the experiment are pre-determined before the experiment begins, and participants will be provided with a password-protected spreadsheet containing the outcomes of the draws used in the experiment. The password for the spreadsheet will be provided to participants only after they have completed the experiment. We plan to collect data from 150 participants for each of our four treatments, resulting in a total sample of 600 participants. Treatment assignment is done at the individual level.

## 3 Research questions and analysis

The raw data consists of participants' belief reports about risky and ambiguous events for implied objective probabilities $p \in \{0.2, 0.5, 0.8\}$. We use three outcome variables to measure the accuracy of participants' belief reports. The first outcome variable is a dummy variable that classifies whether the reported belief deviates from the implied objective probability.[1] The second outcome variable is the absolute distance of the reported belief from the implied objective probability. The third outcome variable is the absolute distance of the reported belief from the midpoint 0.5.

[1]For robustness, we will replicate the analysis allowing for small errors that deviate by no more than 2 percentage points from the implied objective probabilities.

In a first step, we will compare the accuracy of participants' belief reports between ambiguous and risky events to answer the following research questions:

**RQ 1** *Are there more distortions under ambiguity versus risk? What are the directions of the distortions?*

In a second step, we will use our between-subjects variation in the stake size and the level of detail used to explain the BSR to answer the following research questions:

**RQ 2**

*(a) Do the distortions identified in RQ 1 depend on stakes?*

*(b) Do the distortions identified in RQ 1 depend on level of detail used to explain the BSR?*

In a third step, we correlate the observed distortions in belief reports with ambiguity preferences and we test whether the distortions are in line with theory. Specifically, theory predicts that the BSR leads to distortions of probabilistic beliefs: (i) towards the midpoint for ambiguity-averse individuals, and (ii) towards the extremes for ambiguity-seeking individuals. The questions we therefore ask are:

**RQ 3**

*(a) Can ambiguity preferences explain the observed distortions?*

*(b) Is the relationship between ambiguity preferences and distortions consistent with theory?*

**Heterogeneity.** We will conduct the analysis separately based on implied objective probability $p \in \{0.2, 0.5, 0.8\}$.

**Robustness.** We will also conduct robustness checks by excluding participants who were confused or misunderstood the instructions. To this end, we will exclude participants who fail the control questions, who report beliefs for the complementary event in Part A, or who choose dominated options in Part B and Part C of the experiment.

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