

# Experimental Design: Cognitive Skills and Economic Preferences in the Fund Industry

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This version: October 19, 2021

# 1 The Experiment

We exploit two sources of data: first, we collected data on cognitive skills and economic preferences by means of online experiments and, second, we matched the empirical fund time series with the experimental data of the fund managers who participated in the experiment. To ensure anonymity, fund managers' identities were replaced by randomly generated unique identifiers to match the experimental data with depersonalized, empirical fund data from various databases.

We contacted approximately 900 fund managers via hard-copy letters and/or e-mails in which the study was outlined and which included personalized login credentials for participation in the online experiment. Ninety-four fund managers completed the experiment.<sup>1</sup> Fund managers were informed about the anonymous matching of the experimental data with the corresponding fund data. With the decision to participate, fund managers acknowledged to accept the informed consent of the experiment.

The experimental tasks were divided into three parts: (i) cognitive skills, (ii) incentivized economic preferences, and (iii) personality traits. Importantly, fund managers did not receive immediate feedback after each task, but were told in advance that they can select whether they want to receive feedback and background information on the experimental tasks after data collection has been completed. This was done to provide additional incentives to the fund managers to participate and to provide full disclosure of the background of the experiment. Upon completion of the experiment, one of the incentivized tasks was randomly chosen to determine the subjects' payout. In addition to their earnings from the corresponding task, subjects received a fixed participation fee of €25. Details on the experimental procedure and the feedback can be found in Appendix 2.<sup>2</sup>

First, to measure fund managers' cognitive skills, we administered three different tasks. For cognitive reflection skills, we compiled a set of five questions taken from the extended cognitive reflection tests (CRT) proposed by Toplak et al. (2014) and Primi et al. (2015). The concept of cognitive reflection rests upon the dual-process theory framework (Kahneman, 2011). The questions in these tests are constructed in a way to have an intuitive, but on reflection incorrect, response put forward by System 1; the correct response requires the elaborate activation of System 2.<sup>3</sup> To obtain a score for fluid intelligence, we conducted a task similar to Corngnet et al. (2018), presenting 18 items from the Raven's Advanced Progressive Matrices (APM; Raven, 2000). For each item, subjects have to recognize the geometric pattern in a sequence and identify the missing element. The main objective of this test is to measure subjects' ability to solve novel problems, which is why it is also used to measure IQ. One additional advantage is that it can discriminate well even among high-IQ subjects. To measure theory of mind skills (TOM), we used 18 items of the "Reading-the-Eyes-in-the-Mind"-test proposed by Baron-Cohen et al. (2001). In this test, subjects are shown photographs of the eye region of different people and choose one of four feelings that best describe the mental state of the person whose eyes are shown. This test

<sup>1</sup> The total number of 900 invitations includes undelivered and returned mails, bounce-back e-mails, outdated or invalid (e-mail) addresses, etc. Thus, the response rate of roughly 10% should be considered being a conservative lower bound.

<sup>2</sup> The software, including all instructions as used for the data collection, is available for download as a zipped *oTree* project at <https://osf.io/dq3t8/> and as a live demo version via <https://fea-2018-en.herokuapp.com>.

<sup>3</sup> For illustrative purposes, this is one of the questions: "Jerry received both the 15<sup>th</sup> highest and the 15<sup>th</sup> lowest mark in the class. How many students are in the class?" (Toplak et al., 2014). The (incorrect) intuitive answer (30 students) can be "overruled" upon reflection (29 students), which requires effortful System 2 processes.

measures one’s capacity to infer others’ intentions, which, for instance, is important in detecting the information disseminated by the behavior of other market participants (Bruguier et al., 2010).<sup>4</sup>

Second, to measure economic preferences of the fund managers, we administered four incentivized experiments. Subjects were informed that, at the end of the experiment, one of these tasks would be randomly chosen and their decision in the respective task would determine their payout. Risk attitudes and inter-temporal preferences were elicited as in Falk et al. (2018). The task for loss tolerance was adapted from the procedure of Gaechter et al. (2010), while ambiguity tolerance was measured following the design introduced by Dimmock et al. (2016). We increased consistency and comparability of the experiments by presenting all tasks in a staircase framework (see Figure 2 for one example following Falk et al., 2018). In this setting, subjects face a set of path dependent decisions, offering two choices each. Along these decisions, one option stays the same, while the second option depends on the previous choice. Compared to single and multiple price list formats, this procedure offers the advantage to be concise without forfeiting precision in eliciting points of indifference. Moreover, as subjects are not informed about the staircase properties of the task, it is incentive-compatible.

In the risk preferences task, subjects first had to choose between a lottery paying €60 or €0 with equal probability and a safe payment of €32. Subjects who preferred the lottery in the first stage were presented a higher safe payment in the second stage, while subjects who preferred the safe payment were presented a lower safe payment in the second stage. After four stages, this design allows to pin down a narrow interval for the subjects’ certainty equivalents and hence an estimate of their risk preferences. Clearly, those subjects with high certainty equivalents are considered to show high levels of risk-tolerance. The payout of the safe alternative varied from €4 to €60.

In the time preferences task, the first decision problem asked subjects whether they preferred a payment of €20 today or a payment of €31 in 6 months. Those who selected the payment today were presented a higher future payment in the second stage while those who went with the future payment were presented a lower future payment in the second stage. Iterating this procedure reveals the implicit time discounting rate of the subjects. Note that we drop the variable on inter-temporal preferences (PATIENCE) from the main analysis. The reason is that we lost part of the observations on PATIENCE due to a runtime error issue with this task (around 10% of the sample), and therefore including this variable would result in a smaller sample. We show, in the robustness section, that all the significant results from the main analysis remain robust when PATIENCE is added to analysis.

The loss aversion task started with the question whether subjects preferred to participate in a lottery that pays €22 or €−12 with equal probability. The positive payoff of €22 stayed the same in all questions. Subjects who rejected the lottery were presented with a lower negative payoff in the second stage while subjects who accepted the lottery were presented with a higher potential loss in the second stage. Iterating this procedure reveals the maximum loss subjects were willing to accept in order to obtain the chance of winning €22. According to this logic, subjects with a high tolerable maximum loss are

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<sup>4</sup> For the Raven’s Advanced Progressive Matrices (APM) and the “Reading-the-Eyes-in-the-Mind”-test (TOM), we used shortened versions. The original tasks comprise 36 questions each, out of which we took every second question, starting with the first one of the original task. This was done to keep the overall time needed to complete the survey as short as possible without losing explanatory power. See also Bilker et al. (2012) and Olderbak et al. (2015) for data and a discussion on the usefulness of shortened versions of the APM- and the TOM-tests, respectively.

the ones with high levels of loss tolerance. The range of varying negative payouts in the lottery varied from €-22.50 to €-1.50.<sup>5</sup>

In the ambiguity preferences task, the first decision problem asked subjects to choose between two lotteries. Each lottery offered the chance to win €60 or €0. While the probability of winning €60 was known to be 50% in one of the lotteries (risk), it was unknown in the other lottery (ambiguity). The ambiguous lottery remained unchanged throughout the task. Subjects who chose the risky lottery were presented with a new risky lottery offering a lower known probability of winning in the second stage, while subjects who chose the ambiguous lottery were presented a new risky lottery offering a higher known probability of winning in the second stage. Iterating this procedure reveals the matching probability at which subjects are indifferent between the ambiguous and the risky lottery. Thus, subjects who predominantly select the ambiguous lottery are the ones with high levels of ambiguity tolerance. The probabilities for winning €60 in the risky lottery ranged from 7% to 93%.

Third, we ran a test on measuring fund managers' attitudes towards competition. We used the 5-item subscale of the Work and Family Orientation (wofo) questionnaire proposed by Helmreich and Spence (1978), which is a widely used psychometric measure of individuals' self-assessed competitiveness, which was previously used in experiments with financial professionals (Kirchler et al., 2020).<sup>6</sup>

Questions on demographics concluded the experiment. In total, 94 fund managers completed the experiment, which, from an empirical perspective, might sound relatively low. However, in experimental studies with professional subjects, these numbers are in the upper range of comparable research.<sup>7</sup> We lose one fund manager, because we are not able to match at least one fund to him/her, and we lose one additional manager when excluding certain funds from the sample. Consequently, our base sample consists of 92 fund managers. The average age of the 92 fund managers in our final sample was 44 years, with an average tenure in the finance industry of 18 years. 95% of the fund managers were male.

The experiment was programmed in *oTree* (Chen et al., 2016), utilizing the ready-made applications introduced by Holzmeister (2017). The experimental sessions were conducted in December 2017 and January 2018. Completing the online experiment took fund managers on average 32 minutes (*SD* of 9 minutes). Payout to the subjects was administered via a third party specialized on micro-payments or via bank transfer.

Table 1 provides a descriptive overview of the experimental results. For the econometric analyses, we *z*-standardize the cognitive skill and competitiveness measures by subtracting means and dividing by standard deviations. This does not affect *t*-statistics, but it makes the economic interpretation of

<sup>5</sup> Note that this parametrization together with the participation fee of €25 ensured that subjects could not incur losses in the experiment.

<sup>6</sup> Subjects answered the following five questions: "I enjoy working in situations involving competition with others"; "It is important to me to perform better than others on a task"; "I feel that winning is important in both work and games"; "It annoys me when other people perform better than I do"; "I try harder when I'm in competition with other people". The answers were provided on a Likert scale ranging from 1 (I do not agree at all) to 5 (I fully agree). The sum over all five questions finally enters our data analyses.

<sup>7</sup> For instance, Haigh and List (2005) run their study with 54 finance professionals, Cohn et al. (2014) tested 128 finance professionals—split across two experimental treatments, and Bodnaruk and Simonov (2016) conducted their fund manager study with 68 subjects and only use 52 managers in their main analysis.

**Table 1: Summary statistics of scores in the experimental tasks ( $n = 92$ ).**

<i>Task (Variable)</i>	Mean	SD	Min	Max
CRT	3.97	1.09	1	5
APM	9.81	2.86	1	16
TOM	11.48	2.45	4	16
RISK TOLERANCE	27.52	6.94	10	50
LOSS TOLERANCE	18.08	5.50	2.25	23.25
AMBIGUITY TOLERANCE	39.96	14.04	4	78
COMPETITIVENESS	26.59	4.53	14	35

*Note:* The cognitive reflection test consisted of 5 questions (CRT). The task measuring fluid intelligence comprised of 18 questions (APM). The “Reading-the-Eyes-in-the-Mind”-test measuring theory of mind comprised of 18 questions (TOM). The score for risk tolerance reflects the elicited certainty equivalent for a lottery paying €60 or €0 with equal probability (RISK TOLERANCE). The score for loss tolerance reflects the maximum potential loss subjects were willing to accept in order to have the chance of winning €22 (LOSS TOLERANCE). The score for ambiguity tolerance represents the matching probability (in %) that left subjects indifferent between a risky lottery with the respective probability of winning and an ambiguous lottery with an unknown probability of winning (AMBIGUITY TOLERANCE; both lotteries paid €60 in the case of winning and €0 else). Competitiveness was measured as the sum of all five questions of the wofo survey with Likert-scales ranging from 1 (“I do not agree at all”) to 7 (“I fully agree”) each (COMPETITIVENESS).

the corresponding coefficients more meaningful.<sup>8</sup> For the economic preference tasks, we conduct our analysis using the original metrics of the elicitation procedures.

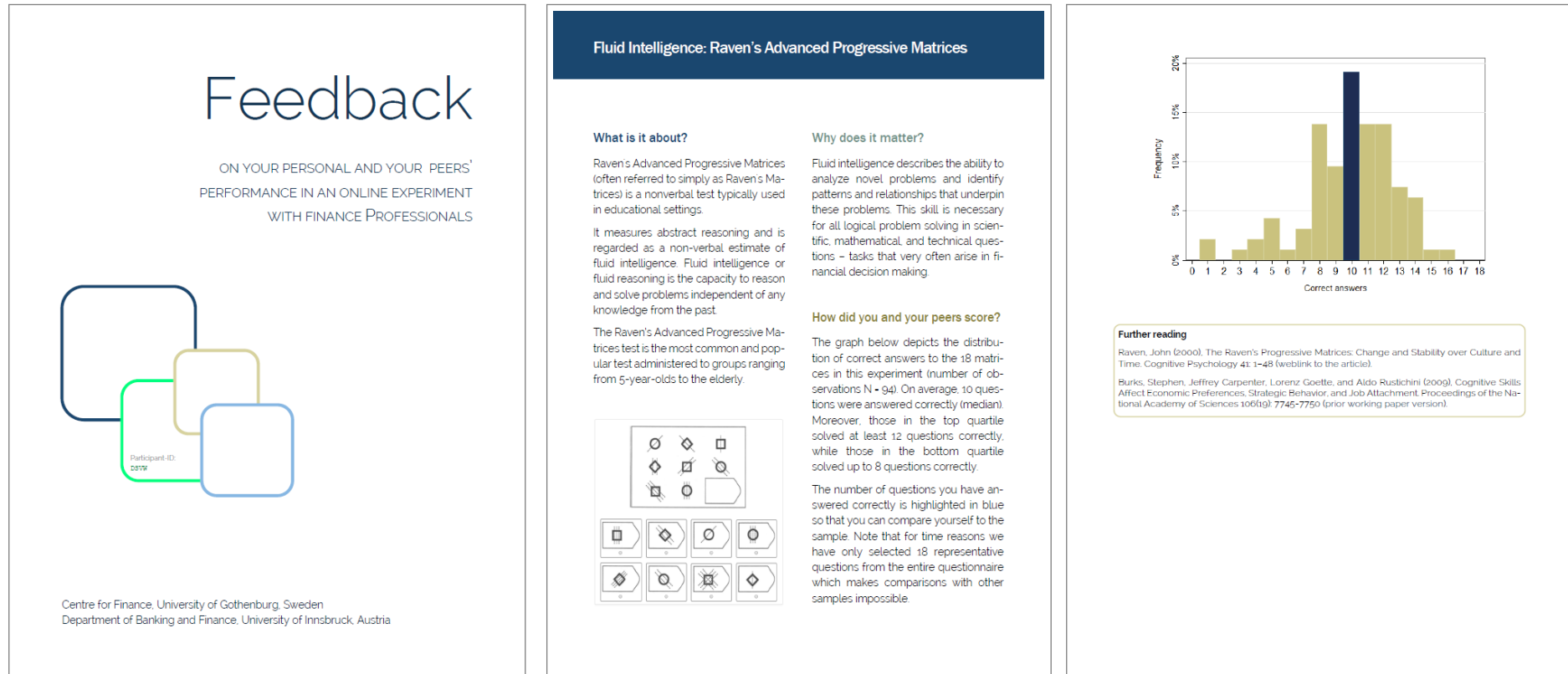
## 2 Additional Details on the Experiment

In this section,<sup>9</sup> the experimental tasks, the feedback map for the fund managers, and results of the various experimental tasks are described in more detail. The experiment has been conducted online using *oTree* (Chen et al., 2016). The software, including all instructions as used for the data collection, is available for download as a zipped *oTree* project at <https://osf.io/dq3t8/> and as a live demo version via <https://fea-2018-en.herokuapp.com>. Participants have been invited via hard-copy letters and/ or e-mail, based on contact information available via funds’ fact sheets, the webpages of institutions, and *Morningstar*.

At the end of the experiment, fund managers could indicate whether they wished to receive personalized feedback (as a multi-page \*.pdf-file distributed via e-mail) once the data collection has been completed. The feedback maps contained general information about each task and why the measured skill may potentially matter for financial decision-making. Moreover, subjects received their own scores as well as summary statistics about the performance of their peers participating in our experiment. Figure 1 show the title page and, as one example, the feedback pages for Raven’s Advanced Progressive Matrices (APM).

<sup>8</sup> The motivation for standardizing cognitive skill and competitiveness measures is the absence of interpretable economic units. Moreover, accounting for potential differences in scaling among the wofo questions, we also standardized each question separately before computing aggregated competitiveness scores.

<sup>9</sup> This section is taken from the Online Appendix of the original paper.



**Figure 1:** Feedback map: The figure shows the title page (left) and, as one example, the information and feedback provided for the Advanced Progressive Matrices task (APM; middle and right). Background information and feedback comparing the individual performance to all participating peers has been presented in a similar way for all other measures elicited in the experiment.

Below, we provide further details on the experimental protocols of the tasks used to elicit cognitive abilities and economic preferences in the online experiment. Correlations between the measures are summarized in Table 2.

**Fluid Intelligence.** Raven’s Advanced Progressive Matrices (APM; Raven, 2000) are designed to measure fluid intelligence. We presented subjects with 18 increasingly difficult items (instead of the 36 items in the original version) where they had to infer the missing element of a given diagrammatic puzzle. In particular, we used every second item, starting with the first puzzle. For further details, we refer to the demo version of the software (<https://fea-2018-en.herokuapp.com>).

**Cognitive Reflection Test.** Cognitive reflection tests are designed to measure subjects’ ability to consciously reflect on their intuitive responses. These types of tests were first established by Frederick (2005) and have been used widely since. To avoid potential recognition effects by the subjects, we decided to use questions from newer versions of the test proposed by Toplak et al. (2014) and Primi et al. (2015). Each question was displayed on a separate screen; the order has been randomized to avoid order effects. In particular, we included the following five questions (correct answers in parentheses):

- If John can drink one barrel of water in 6 days, and Mary can drink one barrel of water in 12 days, how long would it take them to drink one barrel of water together? (4 days)
- Jerry received both the 15<sup>th</sup> highest and the 15<sup>th</sup> lowest mark in the class. How many students are in the class? (29 students)
- A man buys a pig for \$60, sells it for \$70, buys it back for \$80, and sells it finally for \$90. How much has he made? (\$20)
- If three elves can wrap three toys in one hour, how many elves are needed to wrap six toys in two hours? (3 elves)
- In an athletics team, tall members are three times more likely to win a medal than short members. This year the team has won 60 medals so far. How many of these have been won by short athletes? (15 medals)

**Theory of Mind.** Theory of mind is a social sensitivity-skill that refers to the capacity of “reading the minds” of other people. In the “Reading-the-Mind-in-the-Eyes”-test introduced by Baron-Cohen et al. (2001), subjects have to infer the emotional state of a person from a picture showing only their eye region. In each of 18 trials, subjects had to select the correct emotion from a list of four adjectives. For each of the four potential answers, we provided participants with synonyms and an example sentence using the adjective (describing an emotional state) in an easy-to-understand context. To make sure participants understand the task, we implemented one practice trial, providing them with feedback about whether their choice has been correct. We used a subset of 18 pictures from the original menu of 36 pictures, out of which we took every second question, starting with the first one of the original task. The number of correctly chosen emotions serves as our measure of “reading the mind” skills (TOM). For further details, we refer to the demo version of the software (<https://fea-2018-en.herokuapp.com>).



**Risk Preferences.** The staircase risk elicitation method by Falk et al. (2018) allows to infer a subject's certainty equivalent for a given lottery, ensuring consistent answers. In four iterative, path-dependent questions, subjects decided between a lottery that pays €60 or €0 with equal probability and a certain payment that varies from question to question (see Figure 2 for a graphical representation of the task). Precisely, due to the limited number of iterations, the staircase approach yields intervals for the certainty equivalents. The midpoints of the intervals constitute our measure for subjects risk attitudes (RISK TOLERANCE). The task was implemented using the ICL app put forward by Holzmeister (2017).

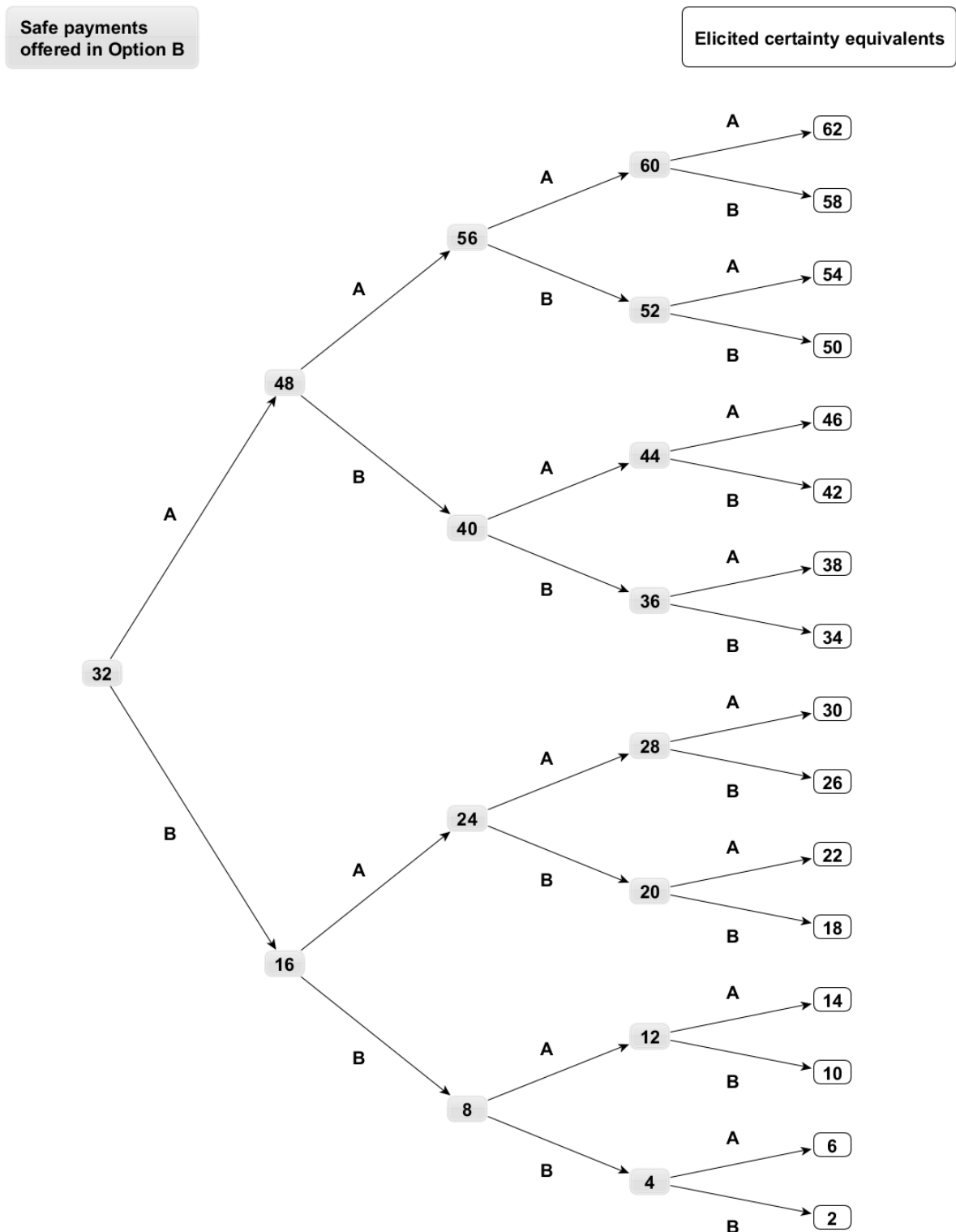
**Time Preferences.** We used the same staircase approach proposed by Falk et al. (2018) to measure time preferences, implemented via a modified version of the ICL app of Holzmeister (2017). In four path-dependent questions, subjects had to decide whether they preferred a payment of €20 today or a certain higher amount in 6 months. The future premium increased in the next question when a subject opted for the payment today and decreased when the subject chose the future payment. Similarly to the risk elicitation task, this approach yields intervals for the time premia required by subjects to wait 6 months. The intervals' midpoints serve as our measure for participants' patience (PATIENCE). For a facilitated interpretation, we compute the future premium subjects were willing to give up in order to receive the payment today (i.e., we multiplied the time premia by  $-1$ ). Thus, higher values represent higher patience.

**Loss Tolerance.** The task to elicit participants' attitudes toward losses is based on the exercise proposed by Gaechter et al. (2010). However, to align the task with the experiments to elicit risk and time preferences, we transformed the elicitation procedure into an interactive, path-dependent series of questions, utilizing the ICL app put forward by Holzmeister (2017). In each question, subjects decided whether they wished to participate in a lottery paying either €22 or some negative amount with equal probability. In the end, the task reveals intervals for each subject's maximum accepted loss in order to have the chance to win €22 (LOSS TOLERANCE).

**Ambiguity Tolerance.** We followed the setup of Dimmock et al. (2016) to elicit ambiguity tolerance. As in the original task, subjects had to choose between two urns containing 100 balls of blue and orange color each. At the end of the experiment, one ball was drawn randomly from the chosen urn. If the ball was blue, the subject would win €60; if the ball was orange, the subject would win nothing. While the distribution of blue and orange balls (i.e., the probability of winning) was known in the first urn, the probability was unknown for the second urn. In the first decision, the known distribution offered a 50% chance of winning. Subjects who chose the known distribution (risk) were presented a lower known probability of winning in the second question, while subject who chose the unknown distribution (ambiguity) were presented a higher known probability of winning in the second question. This procedure reveals a matching probability that leaves subjects indifferent between the risky and the ambiguous alternative, constituting our measure (AMBIGUITY TOLERANCE) of ambiguity preferences.

**Competitiveness.** The Work and Family Orientation (wofo) questionnaire of Helmreich and Spence (1978) is a widely used psychometric measure of individuals' competitiveness. Subjects answered how





**Figure 2:** The staircase risk preference elicitation procedure is based on Falk et al. (2018). The final column shows the midpoints of the elicited intervals for the certainty equivalents ( $\pm 2$  Euros). The iterative methods for eliciting attitudes towards time discounting, losses, and ambiguous outcomes have been implemented based on the same structuring.

strongly they agree with a certain statement about their attitudes towards competition on a scale from 1 to 7. The competitiveness score (COMPETITIVENESS) is then computed as the sum of the individual answers. In particular, participants answered the following five questions:

- I enjoy working in situations involving competition with others.
- It is important to me to perform better than others on a task.
- I feel that winning is important in both work and games.
- It annoys me when other people perform better than I do.
- I try harder when I'm in competition with other people.

**Table 2:** Pearson correlation coefficients between the experimental variables. \*\*  $p < 0.005$ , \*  $p < 0.05$ .  $n = 92$ .

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) CRT	1.00						
(2) APM	0.49**	1.00					
(3) TOM	0.13	0.02	1.00				
(4) RISK TOLERANCE	0.07	0.14	-0.01	1.00			
(5) LOSS TOLERANCE	-0.03	0.00	-0.11	0.24*	1.00		
(6) AMBIGUITY TOLERANCE	0.07	0.22*	0.02	0.06	0.01	1.00	
(7) COMPETITIVENESS	0.15	0.13	0.06	-0.09	-0.11	0.05	1.00

*Note:* CRT stands for the cognitive reflection score, comprised of 5 questions, measuring deliberate thinking. TOM stands for the "Reading-the-Mind-in-the-Eyes"-test, measuring theory of mind skills, i.e., the ability to infer the intention of others. The score for risk preferences (RISK TOLERANCE) reflects the elicited certainty equivalent for a lottery paying €60 or €0 with equal probability, with higher values indicating higher levels of risk tolerance. The measure for attitudes towards losses (LOSS TOLERANCE) reflects the maximum potential loss subjects were willing to accept in order to have the chance of winning €22. Again, the higher the number, the more tolerant towards losses a fund manager is (LOSS TOLERANCE). The score for ambiguity preferences (AMBIGUITY TOLERANCE) represents the matching probability (in %) that leaves subjects indifferent between a risky lottery with a certain probability of winning and an ambiguous lottery with an unknown probability of winning (both lotteries paid €60 in the case of winning and €0 else). COMPETITIVENESS is measured as the sum of the five standardized responses to the subscale of the wofo, answered on scales ranging from 1 to 7 each.

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