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How does visual and verbal representation of returns impact the investment decisions and risk perception of investors?

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Abstract

With a between-subject experimental design the potential impact of information display format for the representation of a financial product's returns on investment propensity and risk perception is examined. This is explored for two presentation formats, namely a graphical representation of returns using a bar chart and a verbal/numerical representation of returns using just numbers and words. It is found that varying the information display format does not affect people's risk perception and on the other side, the impact on investment decisions in terms of aggregate investment amount level is not statistically significant. Overall, it is shown that for people who choose themselves the information display format there is a stronger correlation between self-assessed risk levels and average investment amount than for people who are randomly assigned in one of the two display formats without an option to express their preference. Regarding future research, financial advisors and regulators, this may point towards further consideration of making more than one information display format available when disclosing financial products' information to investors and clients, to facilitate their understanding of all risks involved with the investment.

1. Introduction

Risk is an inherent element of investment and in our life, the encounter with risks is inevitable. Informed investment decisions require careful considerations and an adequate understanding of the financial risks. In financial terms, risk is most often interpreted as volatility and more specifically as the standard deviation of returns. Uncertainty regarding deviation from expected returns exist due to multiple factors which can cause inconsistencies between estimates contained in financial statements and actual outcomes. Examples of such factors are regulatory changes, political instability, inflation, and uncontrollable events such as the COVID-19 pandemic. Proper risk identification, evaluation, and measurement as well as understanding how important is to facilitate people's information processing are fundamental investment concepts and tools for financial decision-making. Information processing refers to how people read, understand, use, and remember information. Information is often structured in complex ways which may prevent people from reading and understanding information given that they have different learning abilities and preferences. Different styles of reading and understanding information may vary implying that one investor may digest information more easily with a visual representation of information, while another investor might benefit more from verbal communication. Hence, people need to be properly informed in order to carefully evaluate and understand the merits and risks of an investment and be able to make informed investment decisions.

The existence of barriers for adequately understanding financial risks could be attributed to the lack of cognitive skills but also to the suboptimal presentation of the risks. Timmermans and Oudhoff (2010) argue that varying the way of presenting information on the quantitative aspect of risks, between verbal terms, numerical estimates, and graphical manner can affect the process of perceiving risk and can also have an impact on investment decisions. According to the authors, visual, numerical, and verbal methods of representing risk each emphasize a different group of aspects, including factuality and precision, awareness, and saliency of risk information. Timmermans and Oudhoff (2010) report a contradiction in literature findings regarding the effect of graphical formats of risk communication on understanding and decision-making. While Lipkus and Hollands (1999) argue that using graphical formats to express probabilities is beneficial and helpful in decision-making in multiple ways, Edwards et al. (2006), find no such effects after evaluating the effects of information provision on decision-making using a range of display formats including graphical and numerical representations. Analyzing how a visual format and a combination of verbal and numerical display formats affect investment decisions can contribute in filling similar gaps in literature concerning the impact of different risk representations and also point towards specific directions as to the best way of communicating financial risks under different circumstances. For this research, different circumstances mean differences in risk attitudes of investors, differences in the level of their financial literacy or other personal characteristics, and giving or not giving people the chance to express their preference for a particular display format.

The purpose of the present study is to explore whether different ways of displaying information can lead to different types of investment behaviour like an increase or decrease in investment propensity and risk taking. In particular, the aim is to explore what type of information people actually prefer to receive when it comes to financial information for investment decisions and check whether one's own choice can be actually helpful for making better decisions, tailored to their risk profile. By presenting information in different ways and analysing the impact this can have on decision-making, this thesis provides insights for a deeper understanding of decisions and how individual choices may help or hinder their optimality based on risk preferences.

Risk perception is one of the key drivers of investor decision-making (Hoffmann et al., 2015) and different modes of information processing could have a significant role in the causal pathway of this effect. For example, Bachler et al. (2021) find that decision-making quality can be influenced by presentation format (graphical vs. tabular) and the complexity of different ways in which choices can be presented, while they identify interaction effects between these two presentation formats and cognitive skills. Focusing on the quality of decision-making concerning investment allocation choices, the authors' findings suggest that graphical presentation formats lead to low decision-making quality scores except from when the choice architecture is simplified and that tabular presentation formats combined with complex or simplified choice architecture are disadvantageous for people with relatively lower fluid intelligence scores or relatively lower numeracy scores respectively, showing that fluid intelligence and numeracy play a role as well.

Glaser et al. (2019) find that varying the presentation format of financial market information on past performance has an impact on an individual's financial market expectations. Specifically, the authors show that when people are asked to forecast returns as an alternative to prices, they have higher expectations while if they are shown return charts rather than price charts their expectations are lower. Bateman et al. (2014) show that different presentation styles of describing risk affect retirement savings portfolio decisions more than large variations in underlying risk, suggesting also that fund member's cognitive processing of risk information depends on template, basic knowledge, expectations and skills. Interestingly, risk-taking behaviour in investments as well as the ability of recalling the risk-return profile of financial products can be partly relied upon the presence of experience sampling in the risk presentation mode (Kaufmann et al., 2013). Experience sampling refers to giving people the opportunity to sample possible outcomes before making a decision and somehow give them a taste of the realization of possible profits or losses based on the risks involved. Evidently, using experience sampling as a method of communicating risk may reduce biases like the overestimation of the probability of loss and increase decision commitment, confidence, and recall ability, leading to higher risky allocations (Kaufmann et al., 2013).

This thesis adds to these strands of research with the motivation being the challenge of understanding the behaviour of investors and evaluating the impact of different information display formats for presenting returns on investments before an investment decision-making task. Specifically, the research question addressed is the following:

Research Question

Does graphical or a combination of verbal and numerical representation of risks and returns impact the investment decisions and risk perception of investors?

The thesis also aims to answer the following sub-question: "Does giving the option to choose which type of risk representation to see actually help or hinder the quality of investment decision-making?"

The experimental design of this thesis also examines whether the correlation between subjects' self-assessed risk levels and the amount invested in the risky investment fund is stronger or weaker when subjects have the option to choose themselves the risk representation format compared to the other two treatments where they do not. On average, it is expected that people with a lower risk tolerance will take less risk and invest less money in the risky investment fund than people who are more risk seeking based on their self-assessed risk-levels. Given the premise that the risk premium of risk averse people is relatively higher than that of risk neutral and risk seeking people, meaning that a risk averse investor would have a preference for avoiding risks and ending up with lower returns rather than taking higher risks with higher returns, it is implied that a high-quality investment decision for risk averse people should be one characterised by low risk-taking behaviour and lower amounts invested in the risky investment fund. However, this assumption comes with the drawback of subjectiveness of each individual's judgment, which is discussed in the limitations section.

To address the research question of the thesis, a between-subject design experiment with three treatments is conducted in which participants are asked to choose how to invest their hypothetical endowment between a risk-free asset with a fixed return of 1.7% and a risky investment fund with an expected return of 2.5% and a standard deviation of 2.13. In these three treatments, randomly allocated subjects receive all relevant information about the two financial products either graphically with more visual characteristics or verbally and numerically in plain terms, with subjects in the third treatment having also the option to choose between these two ways. Before proceeding with their choice of how to invest, participants are also informed that their total hypothetical payoff is a sum of their payoff from the amount they decide to invest in the risky investment fund and their payoff from the amount they decide to invest in the risk-free asset. It is clarified that the payoff from investments in the risky investment fund is determined by a random draw from the given distribution that is presented, while the returns coming from the risk-free asset are constant, safe, and known in advance.

2. Literature Review

People tend to rely on subjective judgments about the characteristics, severity, and likelihood of risk. Research on risk perception analyses the factors that influence how people perceive and experience risk. The literature review section starts by providing a definition for risk perception followed by findings on some of the factors that can influence individual risk perception and what their actual impact is. Then, the literature review focuses on the findings of experimental finance studies which observe the effect of graphical and verbal representation of risk on investment decisions and perceived risk. Following this, the literature review closes with a close look at evidence regarding the relationship of investment decisions and the factors influencing risk perception, for example personal characteristics such as risk attitudes and financial literacy levels. Overall, literature suggests that there can be many factors both within and outside the technical context of communicating risk to investors, which can affect not only risk perception, but also investment behaviour and financial decision-making.

2.1. Risk perception

Theory suggests that risk perception and expectations are fundamental elements of investing, able to drive investment propensity and intentions (Borsboom and Zeisberger, 2020). Ricciardi (2007) defines risk perception as “the way people “see” or “feel” regarding a potential danger or hazard”, underlining its subjectiveness due to the variation in people’s estimations of how risky a situation is (Vai et al., 2020). Within the financial and investment context, this potential danger refers to the possibility of money loss after investing in financial products. According to Renn (1990), intuitive heuristics, associations with the sources of risk, and social amplification of risk are among the most crucial factors that directly affect risk perception. While processing information some people cannot modify the exact same information to formats other than the provided one (Payne et al., 1993). Thus, financial decision-making is rather dependent on the context and salience of the presented information as well as the way it is perceived. Hence, without meaning that risk perception equals risk taking in investment decisions, understanding how people actually make investment decisions requires analysing and shedding light on the main drivers of investor risk perception and potential predictors of investment propensity.

While traditional finance has always been relied upon the theory that investors are rational when they make investment decisions, behavioural studies have proven that their decisions are sometimes guided by psychological feelings. Psychology is an area of special interest for financial professionals and behavioural economists since it is the basis of irrationality, the principal feature of behavioural finance. For example, Tversky and Kahneman (1981) introduced the concept of framing which refers to the way in which a choice or a piece of information can be presented and proved that psychological factors influence the process of evaluating probabilities and decision-making, leading to systematic changes in preferences even when the same situation is described in a different way. Literature suggests that there are many factors able to influence risk perception and investment propensity, rather than risk measurement tools used to communicate the risks of investments. Munscher et al. (2016) argue that the existing choice architecture frameworks are limited and poorly organized in terms of concept, suggesting a taxonomy of choice architecture techniques including the reframing and simplification of information. According to this paper, a more systematic choice architecture theoretical framework is needed as human behaviour can be altered and nudged towards specific and predictable directions with choice architecture interventions that target the constraints and biases of human decision-making. With the aim of protecting investors and improving the quality of their financial choices, information can be reframed and simplified by changing the way it is presented while keeping content the same.

Investigating for the effect of varying the scale of the vertical axis in return charts and price charts on risk perception, investment propensity, and return expectations, Huber and Huber (2019) find that even if there are no differences in the underlying volatility, shortening the length of the scale of the vertical axis remarkably increases the subjective judgment of an individual concerning the risks of an asset. In the paper of Stossel and Meier (2015) it is shown that graphical representations of risk are proved to influence the accuracy of people's assessments on their risk exposure. In more detail, it is shown that when risk is communicated with the use of return bar charts instead of price line charts, perceived risk is significantly increased. This leads to a decrease in risk taking since risk taking behaviour is mostly driven by risk perception (Stossel and Meier, 2015). Analyzing the behavioural effect of the time frame of price charts depicting an asset's past performance, Borsboom et al. (2022) argue that viewing short-term price charts leads to a significantly higher volume in trades compared to viewing long-term price charts, which can be seen as an effect that lowers the level of perceived risk. However, the authors report zero effects of time frame on risk-taking behaviour.

Holzmeister et al. (2020) find that systematic changes in financial risk perception can also be based on the skewness of an asset's returns and suggest that this effect might be the result of loss aversion. The authors show that on average, financial professionals and laypeople perceive negatively skewed assets as being less risky than symmetric assets, while the opposite holds for positively skewed assets which, on average, are perceived to carry more risk than symmetric assets. It is therefore argued, in contrast to expectations, that standard deviation of returns may not be the only factor systematically affecting risk perception, even though it is the most commonly used risk assessment measure in the financial industry. Borsboom and Zeisberger (2020) identify that despite having the exact same return standard deviation, price paths that differ in salient features such as highs and lows may lead to considerably different risk perception by investors. With an examination of the different ways that exist for communicating the risk of investment products, Kaufmann et al. (2013) find that the decision commitment, confidence, and recall ability of investors can be increased by a risk presentation format that contains experience sampling. Hertwig et al. (2004) argue that when people make decisions from experience, they tend to underestimate the chances of rare events, while the opposite holds when decisions are based on description.

In their study, Diacon and Hasseldine (2007) provide evidence that investment fund choices can change by altering the presentation format of financial information between fund values and percent yields. The results of the study show that when people are asked which fund they think is the most suitable means of investing for retirement, the number of respondents who choose an equity fund if they see charts of past performance based on an index of fund values drops if they see the same performance data in terms of annual yields. The authors also show that perceived risk of uncertainty and probability of loss is higher when performance is illustrated using percentage yield terms. However, no effects of the timescale of the provided information regarding past performance on risk perception and investment fund preference are reported, confirming Borsboom et al.'s (2022) study which shows no effects of time frame on average risk-taking, but just an increase in trading activity by shorter time frames. The discoveries of Diacon and Hasseldine (2007) on the effects of salient price path characteristics are confirmed by the study of Sobolev and Harvey (2016), according to which risk perception is affected positively when extra price-change information is revealed on top of price-level information alone.

Evidence also shows that an investor's perception of financial volatility can also be influenced by the preceding patterns of returns (Grosshans and Zeisberger, 2018) and even by graphically salient price-based factors such as average absolute price change, the number of alterations in direction, and the number of peaks and troughs (Duxbury and Summers, 2018). Analysing risk and returns forecasts, Grosshans and Zeisberger (2018) find that if the past price pattern initially starts with a loss followed by a recovery, the satisfaction of investors is higher than in the case of the opposite pattern, independent of the final return's sign. The authors also find that the beliefs and expectations of investors are influenced by the short-term momentum. Nolte and Schneider (2018) attribute the impact of price path characteristics on risk perception to their ability to trigger heuristics like shifting an investor's focus on losses or more recent outcomes.

Overall, these findings provide an overview of the variety of factors that can influence risk perception or trigger psychological mechanisms which can drive investment decisions.

2.2. Graphical representation vs verbal/numerical representation

Experimental studies have shown that forming an investment decision may be influenced by variations in the way information is presented between different formats that exist. Bateman et al. (2014) show that the effect of switching between graphical or textual risk presentations is bigger than the effect of major changes in underlying risk on predicted choices. Interestingly, using a hypothetical asset allocation task for retirement savings, this experimental finance study showed that switching from a textual to a graphical range risk presentation leads to significantly riskier retirement plan account choices. In his paper examining the way visual information is processed by investors to form asset-value expectations and decide how to invest based on their beliefs, Duclos (2015) shows that graphical displays of financial information are able to bias an individual's evaluation and therefore, their investment decisions. The paper shows that when the last direction of an asset's value ends downwards (upwards), people's willingness to invest is less (more) independent of the risks involved, attributing this effect to end-anchoring. The argument saying that risk perception for financial products is affected by the way financial information is disclosed is further supported by Linciano et al. (2018) who argue that perceived complexity is the main driver of risk perception. The authors provide evidence that this variable leads to an increase in risk perception as the saliency of information does, confirming the findings of Weber et al. (2005) who show that presenting returns using a distribution graph instead of a bar graph gives rise to asset risk estimates due to the increased saliency of endpoints (extreme values).

Overall, these findings (Bateman et al., 2014; Linciano et al., 2018; Weber et al., 2005) let us hypothesize that *visual/graphical representation of returns will lead to lower perceived riskiness scores and produce riskier investment decision outcomes than verbal/numerical representation, reflected in the average amount of money invested in the risky investment fund.* Evidence from these findings suggests that graphical representation will on average lead to more money invested in the risky investment fund. This is in line with the results of Bateman et al. (2014) who find that presenting risk graphically leads to an increase in risk taking. The hypothesis is also in line with the arguments of Linciano et al. (2018) and the findings of Weber et al. (2005) since the complexity in the graphical representation is relatively lower (Lipkus and Hollands, 1999) and returns are represented using a bar graph. The lower complexity reduces the cognitive effort needed to process risk information and this according to Linciano et al. (2018) leads to a decrease in risk perception which perhaps may be accompanied with an increase in risk taking behaviour and investment propensity in agreement with Bateman et al.'s (2014) findings. Specifically, hypothesis 1 is the following:

Hypothesis 1: *The average amount invested in the risky investment fund will be higher for people who see a graphical representation of returns compared to that of people who see a verbal/numerical representation of returns.*

Focusing on the characteristics of three different presentation formats for the communication of risk, Timmermans and Oudhoff (2010) illustrate that the suitability of some risk representations may vary in different circumstances. For example, the authors argue that using verbal terms for communicating risks, without including numbers, has the advantage of simplicity and practicality specifically in cases where emphasis is put on providing guidance while interpreting risks instead of providing clarity regarding the exact risk size. The disadvantages of verbal risk formats include proneness to miscommunication, large variations in how people interpret verbal labels, and less accuracy. In contrast, using numerical expressions to represent probabilities increases accuracy as well as trustworthiness and it is more convenient for situations where risks are compared. Paradoxically, literature suggests that it is more difficult for laypeople to understand or imagine numerical estimates of risk (Yamagishi, 1997). As for visual displays or graphical formats, on the side of benefits there is the ease by which complicated causal relationships and trends in time can be illustrated as well as the reduced cognitive effort needed to process risk information (Lipkus and Hollands, 1999). While Lipkus and Hollands (1999) report the vividness of graphical formats as a benefit for communicating health risks; for the communication of financial risks, this ability of graphical displays to draw one's attention and generate feelings or underline messages can be considered as a huge disadvantage. This is because graphical display formats can then be inappropriately used to direct people's choices by emphasizing information and triggering heuristics.

Yet, there are people who just prefer a visual learning style, meaning that before processing information they first need to see it. Visual learners understand information more effectively if they are presented in images, diagrams, graphs, and other types of visual stimulation (Ashraf et al., 2013). That is, their learning process passes through the visual path. Similarly, auditory learners understand information better by hearing and listening, using the auditory pathway to process information. However, there is no evidence indicating that any preferred learning method is actually more beneficial for understanding and retaining information. The existence of pros and cons for each display format of presenting risk provides evidence opposing the consolidation of using a single display format every time and for everyone. On the whole, Timmermans and Oudhoff (2010) underline the general need of reducing the cognitive complexity of the information as much as possible in order to keep people from enabling heuristic processing and making low quality decisions.

In the concept of finance, it is essential to examine whether a particular type of beneficial or harmful behaviour, by a specific group of people that share the same characteristics, such as risk attitude, is correlated to a specific display format of communicating risks, visual or verbal/numerical. The results of this research can have important implications to this rationale by providing insights as to which type of information might be better to utilize given different circumstances. Given that investment decisions rely on both individual expectations and preferences, the way information is presented arguably becomes the centre of analysis, specifically when evidence shows that varying the information display format may affect expectations to some extent and that specific groups of people can perhaps be correlated to particular patterns depending on their preferences. The latter is covered by the following sub-chapter on personal characteristics.

2.3. The role of personal characteristics

Literature suggests that financial literacy plays an important role in risk tolerance and investment choices. Bateman et al. (2014) report that for any risk presentation format, there is a positive relationship between high financial literacy and sensitivity to increasing risk levels. Although sufficient financial education does not guarantee better investment performance, low levels of factual financial knowledge among investors can result in negative consequences (Pellinen et al., 2011). Fluid intelligence and numeracy skills are proven to be some of the key factors as well. Bachler et al. (2021) find that graphical presentation format for displaying information on investment possibilities, in combination with high environmental complexity, decreases the decision-making quality of investors. Conversely, with graphical presentation and a more simplified choice architecture, the quality of investment decisions is higher. Interestingly though, it turns out that, for people with lower fluid intelligence particularly, the use of tabular displays makes the construction of portfolios harder. At the same time, the combination of tabular display and low environmental complexity is proven to be disadvantageous for investors with poor numeracy skills. This indicates that in addition to presentation format and decision environment, financial decision-making can be highly influenced by personal characteristics as well.

Literature also suggests that there is a relationship between investment choices and behavioural factors. In a study surveying mainly undergraduate business students in Kazakhstan, who have received basic financial education, Pak and Mahmood (2015) find that an individual's risk tolerance behaviour is driven to some point by personality traits. Analysing the systematic correlation between risk attitudes and market behaviour by observing binary lottery choices and market activity (total number of bids and asks), Fellner and Maciejovsky (2007) find that the more risk averse an individual is, the less the total market activity and the less the number of trades. Using a questionnaire to analyse the factors driving the risk-taking behaviour of investors, Nosic and Weber (2010) find that portfolio choices are affected by subjective financial risk attitudes, meaning the self-assessed willingness of participants to take financial risks. Specifically, their results suggest that on average, subjects with lower levels of risk aversion in the financial domain invest into more risky portfolios. To highlight the importance of homogeneity between a risk preferences assessment tool and the circumstances surrounding risk taking decisions, Weber (2010) argues that risk taking is influenced by domain specific variables that differ in familiarity, such as the way in which information about uncertain outcomes is acquired. Moreover, risk preferences can influence investment propensity (Holzmeister et al., 2020), indicating that risk attitudes can be reflected in investment choices.

In general, these findings support the argument that there is a correlation between risk attitudes and risk taking. This correlation can be reflected in investment propensity, assuming that on average more risk averse individuals are willing to take less risks in their investments compared to less risk averse individuals. This literature backed assumption is the basis of the second hypothesis of the thesis according to which *having the option to choose a risk representation format between graphical and verbal/numerical has a positive impact on the correlation between risk attitudes and investment propensity in the risky investment fund.* The second hypothesis of the thesis is the following:

Hypothesis 2: *The correlation between self-assessed risk levels and investments in the risky investment fund is stronger when subjects choose themselves the information display format than when they do not.*

This way we can test how self-assessed risk levels are correlated with investment choices and whether people actually know in which way information should be disclosed to them so that they can optimize their investment decisions.

3. Methodology

3.1. Data collection

An online survey is conducted using Qualtrics with 242 participants, randomly allocated between three treatment groups, with 90 subjects in the *graphical* treatment, 71 in the *verbal/numerical* treatment, and 81 in the *self-selection* treatment. Subjects were recruited using a URL that was distributed without aiming at any specific target audience. Participants were not informed about the purpose of the study, but they were aware that they were taking part in an experiment conducted as part of a Master's Thesis research project. So, they were not incentivised at all to choose strategically in the one-shot task or any other question.

Summary statistics for the demographic characteristics of participants are displayed in Appendix 1. Demographic data was collected at the end of the questionnaire to control for variables age_range, gender, education_lvl, annua_income_range, and a dummy variable specifying whether or not the respondent studies or works in a finance-related job, finance_field. Out of 242 participants, 168 are male, 69 are female, 4 are non-binary and 1 preferred not to specify. All ages between 18 and 66 and above are represented in the sample, with the mode age range being 18-24 years. As expected, 50.82% of participants are between 18 and 24 years old as the online survey was sent mainly to students. This also explains the overrepresentation of well-educated people in the sample, with 42.98% reporting that they have received at least a Bachelor's degree and 38.02% with at least a Master's degree. 54.54% of participants receive an individual income that is less than 25,000 euros, 21.49% receive

25,000 – 50,000 euros, and 23.97% receive an individual income of more than 50,000. Only 39.26% of the sample studies or works in a finance-related field.

The average time needed to complete the survey was 5 minutes and 52 seconds. On average, subjects who received graphical information needed 6 minutes and 19 seconds for the completion of the survey, while subjects who received verbal/numerical information spent 5 minutes and 14 seconds.

3.2. The experiment

The experiment is conducted using a between subject design where different subjects test each condition to minimize the learning and transfer across conditions as well as the session time needed to complete the survey. After agreeing to participate in the online survey, subjects are put in a hypothetical scenario where they are in control of an endowment of 5,000 euros and are instructed to allocate that complete amount between a risky investment fund and a risk-free asset after the standard deviation of returns is given to them as a measure of the risk involved in these two financial products. The exact instructions given to the participants are presented in Appendix 2. Firstly, the risky investment fund has expected returns of 2.5% which is the calculated average from the available past performance of returns. The return distribution of the risky investment fund is characterized by fluctuations which induce the risk of deviations, both below and above the 2.5% expected return rate. Moreover, there is zero variance in the returns of the risk-free asset whose return rate is constant at 1.7%. This means that investing in the risk-free asset contains zero risk of deviating from the 1.7% rate. In contrast, investing in the risky investment fund contains the risk of investors ending up with returns as low as 0.2%, considerably lower than 1.7% (safe return of the risk-free asset) and 2.5% (expected return of the investment fund). The characteristics of the risky investment fund and the risk-free asset are constructed in such a way that can guarantee a certain level of heterogeneity in investment behaviour to allow for a closer analysis. This is basically achieved by creating a trade-off in the risk and returns between the two financial products, as on the one hand, the risky investment fund comes with variance in the distribution of returns and a relatively higher return in expectations and on the other hand the risk-free asset comes with zero variance, but a lower and safe return rate. Accordingly, the risky investment fund has higher return in expectations than the lower return of the safe asset, but also contains more variance in its return distribution compared to the zero variance in the return of the risk-free asset.

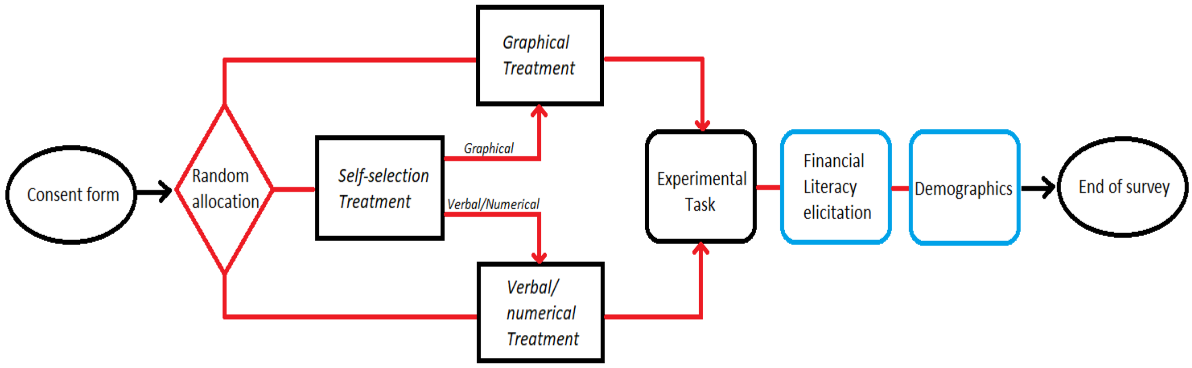
Subjects are informed that the final outcome of their investment is the sum of the returns from the amounts they decide to invest in the risky investment fund and the risk-free asset. While the risk-free asset gives a safe return of 1.7% on the participant's investment, it is clarified that the return on investments put in the risky investment fund is determined by a random draw out of the return distribution that is either shown visually or described verbally to the participants. So, the lowest return that an investor can get by investing in the risky investment fund is intentionally positive at 0.2%, to avoid triggering loss aversion effects that, according to Kahneman and Tversky's (1979, 1991) theory, would lead investors to invest all their endowment in the risk-free asset in order to avoid losses.

For their experimental task, subjects are asked to choose how much of their endowment they would invest in the risky investment fund, assuming that the rest of their endowment is going to be invested in the risk-free asset. Hence, the more money they decide to invest in the investment fund, the higher the level of risk their behaviour exhibits. After the task concerning their investment decision, subjects answered a question for their perceived riskiness regarding the risky investment fund as well as three basic financial literacy questions for the assessment of their financial literacy levels. The purpose of the question regarding the perceived riskiness is to elicit each subject's risk perception and investigate the impact of visual or verbal/numerical representation of returns on risk perception. The question that is used is very similar to the one used by Anzoni and Zeisberger (2016) which asks subjects to answer how risky they perceive an investment to be by stating a rate on a Likert-type scale from 0 (not risky at all) to 7 (extremely risky). The financial literacy of participants is elicited to control for this variable as studies have shown that there is a difference in the investment decisions among people of different financial sophistication levels (Bailey et al., 2011; van Rooij et al., 2011). The three basic financial literary questions are featured in Lusardi and Mitchell's (2007) study. To test for any patterns between risk attitudes and treatment effects such as a correlation of risk preferences and sensitivity to a particular display format, subjects also self-assessed their risk attitude using a scale from 0 (risk aversion) to 7 (risk seeking). An additional question asks participants whether they are studying or working in a finance related field. Controlling for this variable is necessary since the investment decisions of people with a financial background may differ from the investment decisions of people without a background in finance due to gaps in knowledge.

Studying or working in a finance related field could also mean less sensitivity to different formats of representing the returns of a financial product. Lastly, subjects answered a short questionnaire on demographics, for the collection of data on age, gender, education, and individual income. These personal characteristics are chosen to be control variables since prior literature suggests that they are related to investment decisions and risk taking. Specifically, gender and age are variables found to be correlated with trading activity (Borsboom et al., 2022). Results show that higher age (Malmendier and Nager, 2011) as well as being female (Charness and Gneezy, 2012) have a negative relationship with risk taking. As for education and income, according to Stolper (2018), these variables have both been found to predict financial literacy levels. These variables are often included as control variables that may affect predictors and determinants of investment decisions such as risk taking. The same holds for the dummy variable indicating whether or not the responder is studying or working in a finance related field.

Regarding the chosen size of the hypothetical endowment, participants are asked to invest 5000 euros which is the same amount used in the two experimental tasks of Huber and Huber's (2019) study. Lower amounts are avoided based on the assumption that the endowment needs to be high enough to make the situation more realistic and enhance the attention of participants.

Figure 1: Visual representation of the experiment



3.3. Treatments

Subjects are randomly allocated between three treatments. In treatment one, the past returns of the risky investment fund for the last 10 years are graphically shown to the participants and are represented with orange bar charts (see Appendix 2). These returns are all positive and get values ranging from 0.2% up to 5.9%. Meanwhile, the constant rate of returns for the risk-free asset is at 1.7% and is displayed on the same graph with the use of a blue horizontal line. What accompanies this graph is the information on how the final outcome of the investment is calculated, using terms as simple as possible so that everyone can easily understand how the outcome of their investment is determined.

In treatment two, the exact same information is verbally communicated to subjects using words and numbers. With the absence of any graphs, subjects in treatment two are informed about the returns of the risky investment fund and the risk-free asset with bullet points stating the return rate of the risk-free asset, the expected return (=average of returns) of the risky investment fund, the minimum and maximum of the investment fund's returns, and the set of return values that lie within one, two, and three standard deviations from the fund's expected return i.e., the 2.5% mean. Moreover, subjects are informed in the exact same way as in treatment one about how the final outcome of their total investment is calculated.

Furthermore, treatment three gives the option to subjects to choose the type in which they will receive this information, between graphical and numerical. Subjects that are randomly allocated in treatment three are informed about the investment decision they will need to take before having the ability to choose the type of information they will see to learn about the returns and risks connected to the risky investment fund and the risk-free asset.

By varying the type of information used to present investment risks, from graphical format to verbal/numerical format, while keeping all other factors constant, a comprehensive picture is given about the effect of different display formats of information on investment behaviour. This effect is directly tested by comparing the investment decisions (average amount invested) under a visual representation of returns versus the investment decisions under a verbal "stated" representation of returns. The additional hypothesis examined (H2) is whether the correlation between the amount invested in the risky investment fund and self-assessed risk attitudes is higher for the people who have chosen themselves which display format to receive than those who were not given this option. The latter is measured by testing whether there are significant differences in the average amount invested in the risky investment fund between people within the first two treatments versus people of corresponding risk attitudes within the third treatment. This allows to examine whether people actually know which display format is better for them to obtain for the communication of risks and returns in order to increase the quality of their investment decisions.

4. Results

The discussion is initiated with a close look at the influence of the display format of information on risk perception and investment propensity. To test whether graphical representation and verbal/numerical representation of returns lead to different investment amounts, the differences in the average amount of money invested in the risky investment fund across treatment 1 and treatment 2 are analyzed. The analysis is presented among the following dimensions: we first present the summary statistics for the investment propensity of subjects across the first two treatments and show the results of varying the display format (visual vs verbal/numerical) on risk perception and investment propensity. We then analyse if the differences in the average investment amounts across the treatments are significant with the use of the two-sample t-test and four OLS regressions. Afterwards, we focus on testing hypothesis 2 by looking at how self-assessed risk levels are correlated to investment propensity with pairwise comparisons between and within the treatments.

4.1. Experimental Task

The results of the experimental task measuring the average amount of investment in the risky investment fund across the three treatments are shown in Table 1. To reflect the amount each subject decided to invest in the risky investment fund, variable *amount_to_invest* was created. Additionally, to determine which display format was presented to participants before they decide how much to invest, variable *display* was created. The dummy variable *option* was used to distinguish subjects of the *self-selection* treatment from subjects within the other two treatments.

Table 1

Option	Freq.	Mean	Std. Dev.	Min	Max
(1) NO	**161**	**2463.19**	**1048.63**	**0.00**	**5000.00**
Graphical	91	2507.46	1086.46	0.00	5000.00
Numerical	70	2405.64	1002.13	334.00	5000.00
(2) YES	**81**	**2589.89**	**1322.16**	**0.00**	**5000.00**
Graphical	51	2627.41	1156.91	803.00	5000.00
Numerical	30	2526.10	1583.67	0.00	5000.00
Total	**242**	**2505.60**	**1146.26**	**0.00**	**5000.00**

Summary statistics for the dummy variable option depending on amount_to_invest.

The *graphical* representation was shown in 142 observations. As shown in Table 1 of the summary statistics for the experimental task depending on whether subjects were in the *self-*

selection treatment or not, 91 of these observations come from treatment *graphical* with the average amount invested being 2507.46 euros and 51 come from treatment *self-selection* with the average amount invested being 2627.41 euros. The *verbal/numerical* representation contained 100 observations, out of which 70 come from the treatment *numerical* where the average amount invested is 2405.64 euros and 30 come from the treatment *self-selection* where the average amount invested is 2526.10 euros. This sums up 81 observations for the treatment *self-selection* with an average investment amount at 2589.89 euros, a minimum of 0 euros and a maximum of 5000 euros. Therefore, out of 81 subjects who had the option to choose an information display format, 51 preferred the *graphical* representation and 30 preferred the *numerical* representation.

Out of 161 subjects who were randomly allocated to either the *graphical* or the *verbal/numerical* treatment without the option to choose themselves, 91 of them were assigned to the *graphical* treatment and 70 were assigned to the *verbal/numerical* treatment. For the *graphical* treatment itself, the minimum amount invested in the risky investment fund is 0 euros and the maximum is 5000 euros while for the *numerical* treatment itself the minimum investment amount is 334 euros and the maximum is 5000 euros. For the *graphical* treatment within the treatment *self-selection,* the minimum investment amount is 803 euros and the maximum is 5000 euros while for the *numerical* treatment within the treatment *self-selection* the minimum investment amount is 0 euros and the maximum is 5000 euros.

From Table 1 it can be seen that there are differences in the average investment amount when the variable *option* takes the value of 1 and when the variable takes the value of 2 (i.e. when people have the opportunity to choose themselves which type of display format to see and when they do not). Upon the literature-based assumption that investment propensity may be partly driven by the risk attitude, Hypothesis 2 tests whether the correlation between investing more money in the risky investment fund and having higher self-assessed risk levels is stronger when the variable *option* takes the value of 2 (YES) than when the variable *option* takes the value of 1 (NO).

Subjects' self-assessed risk level is represented by the variable *self_assessed_risk_level* which gives the values elicited from the question *"How do you rate your risk-taking behaviour?"* (see Appendix 2) using a scale from 0 (risk averse) to 7 (risk seeking). To have a clear distinction between the three different risk attitudes, from risk averse (low risk) to risk seeking (high risk), participants who rated their risk behaviour from 0 to 2 are labelled as risk averse (1), subjects with a score of 3 and 4 are labelled as risk neutral (2), while subjects with a score from 5 to 7 are considered to be risk seeking (3).

Table 2 shows the number of observations in the data for the variable amount_to_invest according to self-assessed risk level for treatment *graphical* and treatment *numerical.* Table 3 shows the number of observations in the data for the same variable depending on self-assessed risk levels again and display format but only within the *self-selection* treatment.

Table 2

Self_assessed_risk_level	Graphical	Numerical
0	2	-
1	7	3
2	8	7
3	25	15
4	20	20
5	19	17
6	7	6
7	3	2
Total	**91**	**70**

Frequency of amount_to_invest depending on self_assessed_risk_level and display (treatment graphical and treatment numerical only).

Table 3

Self_assessed_risk_level	Graphical	Numerical
0	1	5
1	3	-
2	8	1
3	8	4
4	18	9
5	8	5
6	4	4
7	1	2
Total	**51**	**30**

Frequency of amount_to_invest depending on self_assessed_risk_level and display (treatment self-selection only).

Table 1 and 4 show that on average, subjects who received the information graphically invested 101.82 euros more than subjects who received information verbally/numerically without an option (treatment graphical vs treatment numerical). Table 1 and 5 show that on average, subjects who have chosen to receive the information graphically invested 101.31 euros more than subjects who have chosen to receive the information verbally/numerically (treatment self-selection). Tables 4 and 5 show the average investment amount for each self-assessed risk level, according to treatments *graphical* vs *numerical* alone and within treatment *self-selection* respectively.

Table 4

Self_assessed_risk_level	Graphical	Numerical	Total
0	3010	-	3010
1	2219	2041	2166
2	2021	2115	2065
3	2227	1935	2118
4	2456	2326	2391
5	2759	2868	2810
6	2875	2959	2914
7	4373	2703	3705
Total	**2507**	**2406**	**2463**

Average of amount_to_invest in euros depending on self_assessed_risk_level and display (treatment graphical and treatment numerical only). Numbers for average amount_to_invest are rounded up.

Table 5

Self_assessed_risk_level	Graphical	Numerical	Total
0	5000	1717	2264
1	1668	-	1668
2	2255	5000	2560
3	2048	1849	1982
4	2694	2435	2607
5	2966	2076	2624
6	3648	3128	3388
7	2758	5000	4253
Total	**2627**	**2526**	**2590**

Average of amount_to_invest in euros depending on self_assessed_risk_level and display (treatment self-selection only). Numbers for average amount_to_invest are rounded up.

As a graphical representation of Table 4, Figure 2 shows the average amount of money invested by subjects in the risky investment fund according to display format (treatment *graphical* vs treatment *numerical*) and self-assessed risk level. Similarly, as a graphical representation of Table 5, Figure 3 shows the average amount of money invested by subjects in the risky investment fund according to display format and self-assessed risk level for treatment *self-selection*. The independent variable *amount_to_invest* is measured and presented on a ratio-scale taking values from 0 to 5000.

Figure 2: *Average amount invested according to display format and self-assessed risk level (no option i.e., treatment graphical vs treatment numerical).*

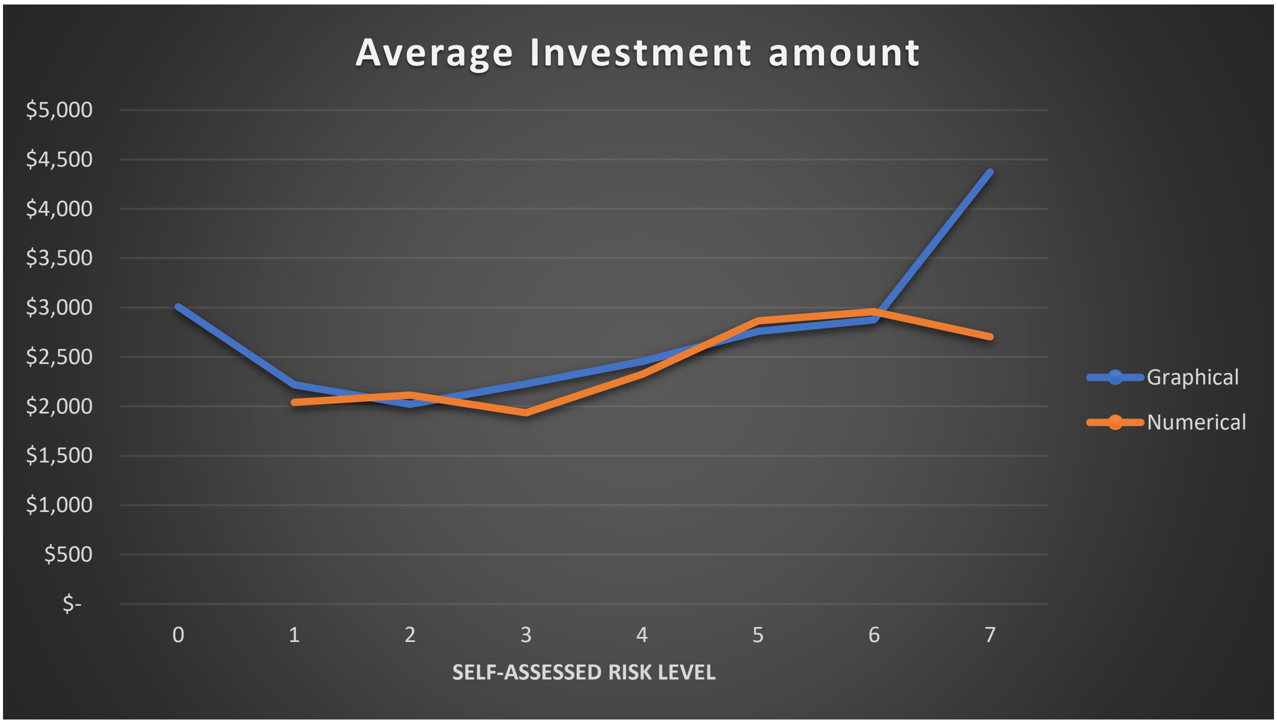
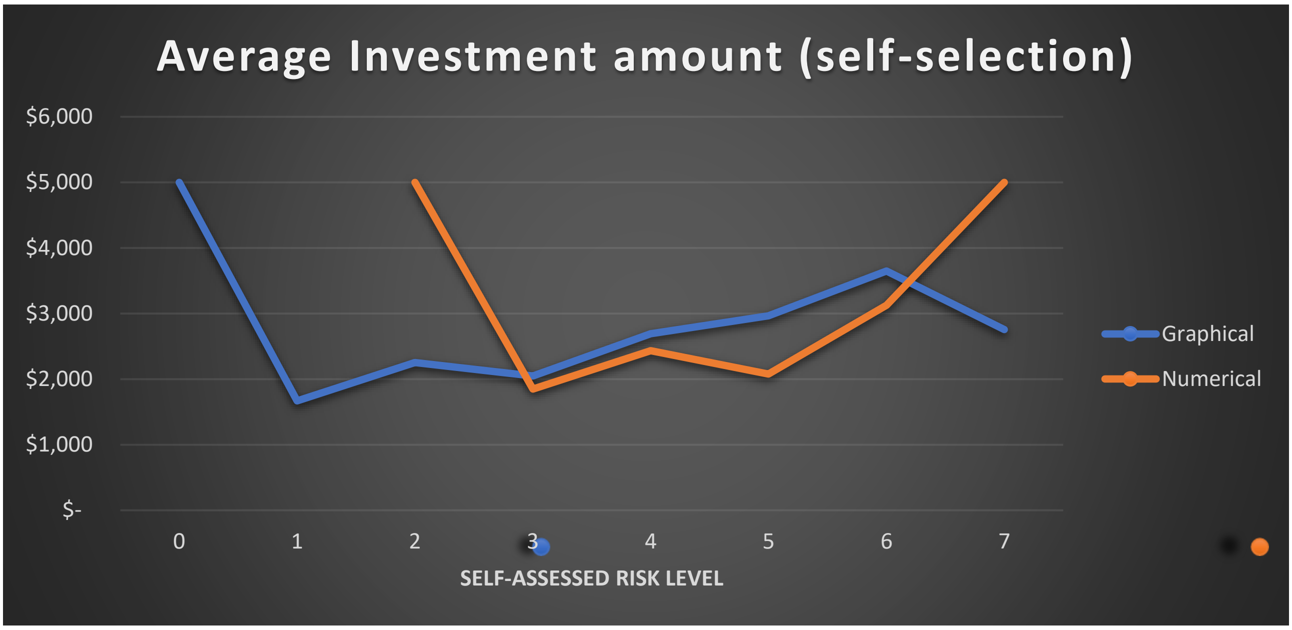


Figure 3: *Average amount invested according to display format and self-assessed risk level (with option i.e., treatment self-selection).*



4.2. Testing of Hypothesis 1 – Differences in average investment amount

As a hypothesis testing tool testing for differences between the means of different groups, a t-test is conducted for hypothesis 1, to determine how significant are the differences between the averages in the amounts invested in the risky investment fund across the two different representations. The scale of measurement for the collected data satisfies the assumption of a continuous scale required for t-tests. Also, the standard deviations across the two treatments do not differ substantially, to satisfy the assumption of homogeneity in variance. Data also needs to be normally distributed with a bell-shaped curve in its distribution (Figure 4 and Figure 5).

Figure 4: *Histogram of the distribution of data in the graphical treatment.*

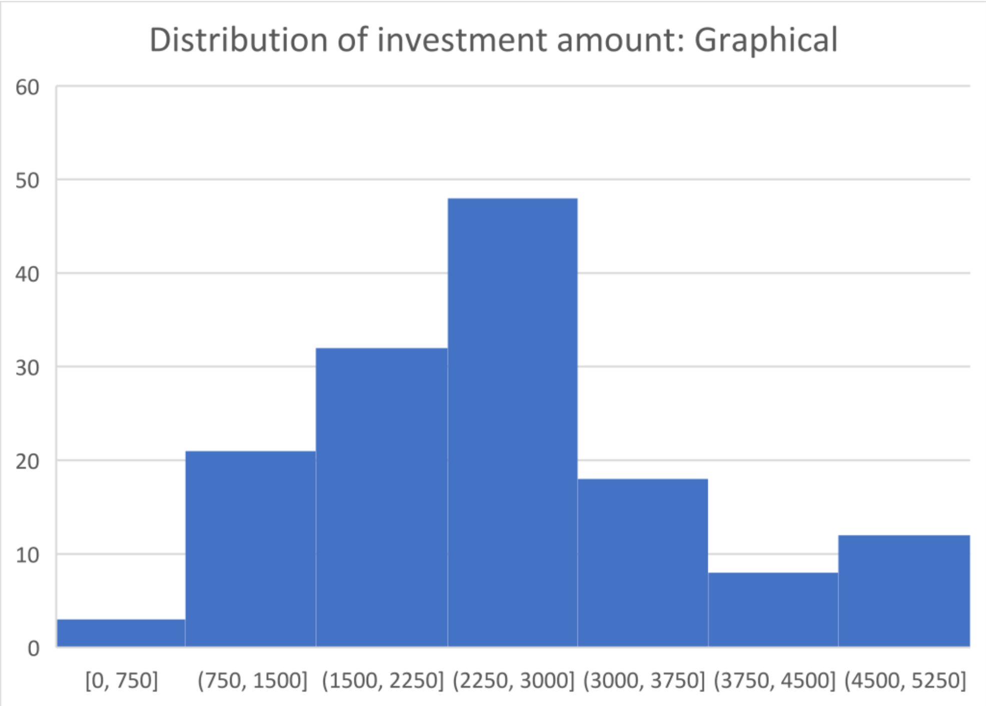
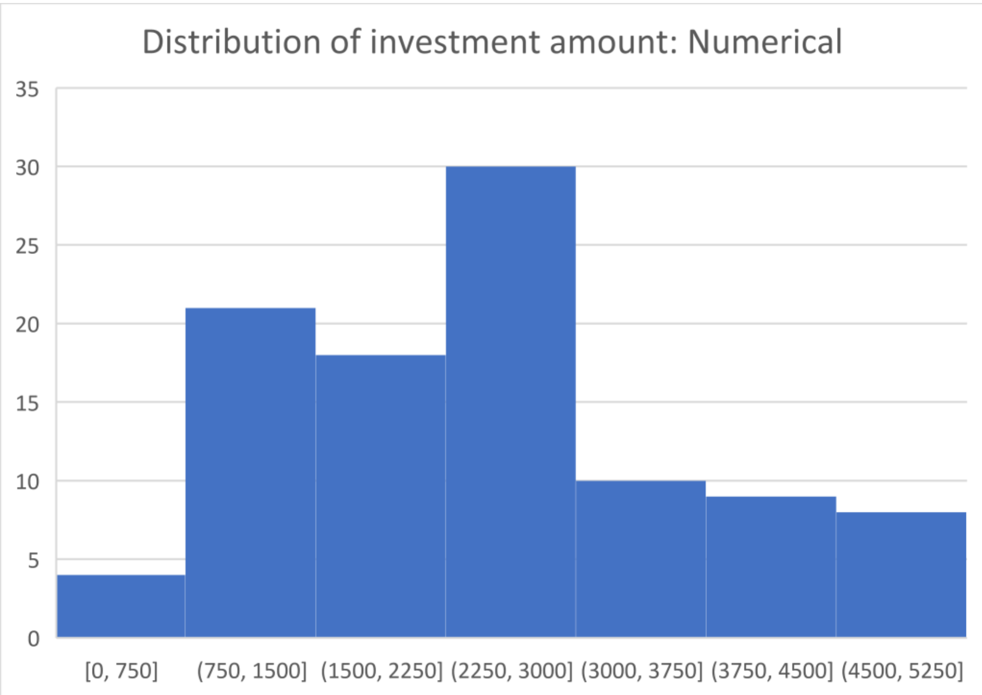


Figure 5: *Histogram of the distribution of data in the verbal/numerical treatment.*



On top of the needed assumptions, the two-sample t-test requires that we have the average investment amount for the *graphical treatment*, the *verbal/numerical treatment*, and the *self-selection treatment* separately, and the standard deviation as well as the sample size for each treatment group. The t-test is conducted to test for the significance of the differences in the average investment amount between the *graphical* and the *numerical* treatment (treatment *graphical* vs treatment *numerical* only) and between the graphical representation and numerical representation within the *self-selection* treatment.

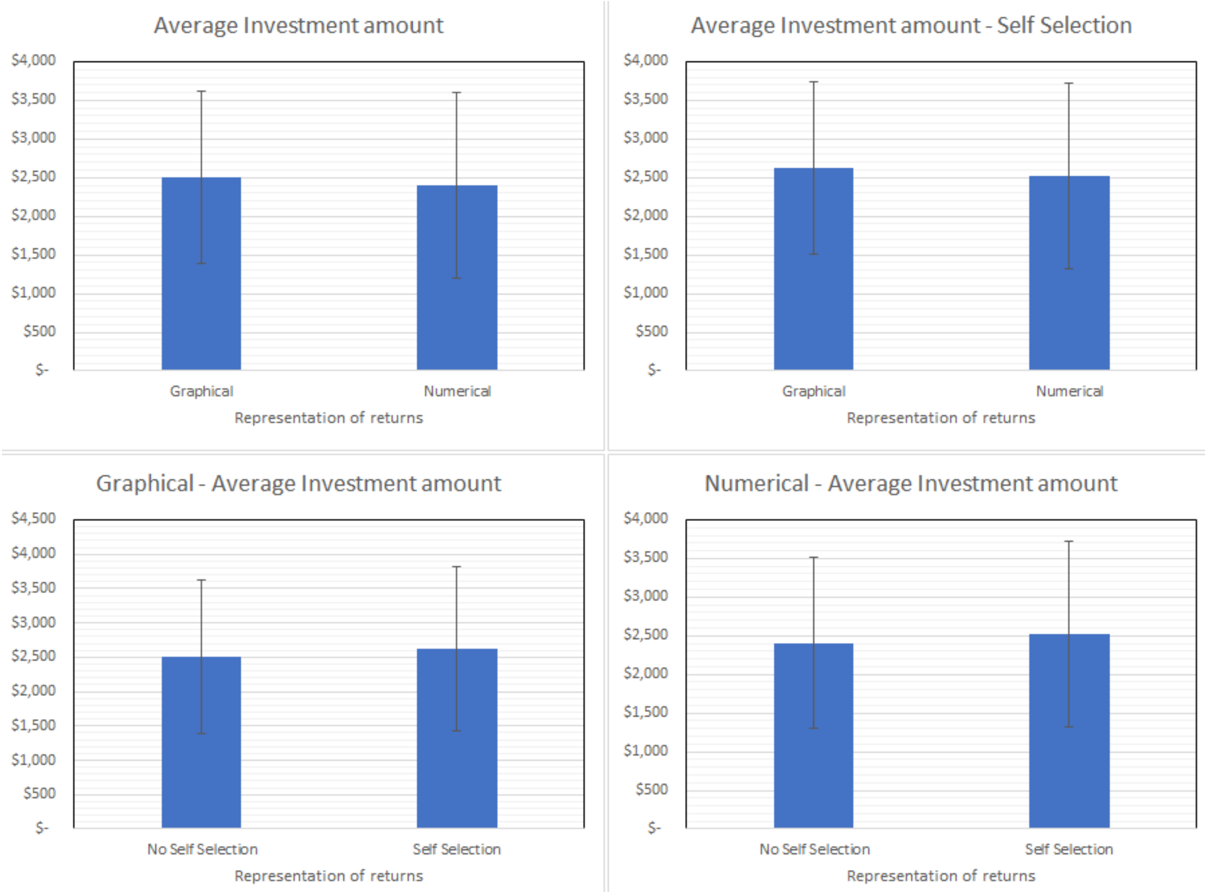
Null Hypothesis (0): *There are no significant differences in the average amount invested.*

Alternative Hypothesis 1: *The difference in the averages of the amount invested is statistically significant.*

After conducting the t-test for the significance of the difference in the average amount invested in the risky investment fund between those who received graphical representation of returns and those who received verbal/numerical representation of returns **without an option**, we find that the delivered p-value is 0.543, higher than the 5% significance level (see Figure 6, *up-left*).

The corresponding t-test for the significance of the differences in the average investment amount of graphical representation and verbal/numerical representation within the *self-selection* treatment gives a p-value of 0.741 which is also higher than the 5% significance level (see Figure 6, *up-right*), meaning that the difference is not statistically significant. Neither the difference in differences (0.51 euros), which is near zero, for the average investment amounts between the first and the second case is statistically significant. This means that for both cases, when participants have the **option** to choose a display format and when participants have **no option**, we cannot reject the null hypothesis that there are no significant differences in the average amount invested and therefore, there is not sufficient evidence to attribute a causal effect on the investment decision of subjects to the variation of the display format or the opportunity to choose.

Figure 6: *Differences in the average investment amount (pairwise comparisons)*



Differences in average investment amount for graphical - no option vs numerical - no option (up-left), graphical – option vs numerical – option (up-right), graphical – no option vs graphical – option (down-left), and numerical – no option vs numerical – option (down-right).

Two more t-tests are conducted to test for the statistical significance of the differences in the average investment amount between graphical representation (treatment *self-selection*) and graphical representation (treatment *graphical*) and between numerical representation (treatment *self-selection*) and numerical representation (treatment *numerical*). For the former case the average amount invested for graphical representation in treatment *self-selection* is 2627.41 euros, 119.95 euros more than the graphical representation in treatment *graphical*. For the latter case the average amount invested in numerical representation within treatment *self-selection* is 2526.10 euros, 120.46 euros more than the numerical representation in treatment *numerical*. In both scenarios, the t-tests give p-values (see Figure 6, *down-left & down-right*) greater than the 5% significance level, meaning that the differences in the average investment amounts are not statistically significant in this case as well.

An OLS regression is run for each of these cases to estimate the coefficients in the relationship of the independent variable amount_to_invest with other dependent variables, controlling for financial literacy, perceived riskiness, age, gender, education level, annual income, and others, which are all included in Appendix 4. As expected, for all four OLS regressions, an increase in one unit for the variable *perceived_riskiness,* which measures how risky subjects think that the investment fund is, leads to a decrease in the amount to invest. This effect is statistically significant at the 5% significance level and it shows that when people perceive the investment fund as being riskier, they decide to invest a less portion of their hypothetical endowment in it. Once again in line with expectations, the OLS regressions show that the investment amount increases with a one unit increase in the variable *self_assessed_risk_level* which measures how risky subjects think their behaviour is. This effect is always statistically at the 5% significance level, meaning that the dependent variable for self-assessed risk levels is a statistically significant factor in the linear regression equation predicting changes in the independent variable *amount_to_invest*.

4.3. Testing of Hypothesis 2 – Correlation coefficients

To see if self-assessed risk attitudes have a higher correlation with actual investment behavior in the *self-selection* treatment than in the other two treatments, we compare their Pearson correlation coefficients that measure the linear correlation between the two sets of data for each case. The Pearson correlation coefficient for both situations, when subjects can choose themselves the information display format and when they cannot, indicates a light positive relationship. In the latter case the Pearson correlation coefficient equals 0.198, but for the *self-selection* treatment, the correlation coefficient is 0.233. This represents a 17.6% increase in the correlation between investment amount and self-assessed risk level when there is an option to choose the information display format than otherwise. Both correlation coefficients are significant at the 5% significance level since their t-values are above the critical values provided by the T distribution table. The t-values are calculated using the following formula, with n being the sample size and r being the sample correlation coefficient.

$$t = \frac{r * \sqrt{n-2}}{\sqrt{1-r^2}}$$

For the self-selection treatment the t-value equals 2.128 while for the graphical and verbal/numerical treatment the t-value equals 2.546.

Null Hypothesis (0): *The correlation is the same.*

Alternative Hypothesis 2: *The correlation is stronger when variable option (=YES) than otherwise (=NO).*

Results, therefore, show that there is a small difference in the correlation of average investment amount and self-assessed risk levels between the *graphical* and *verbal/numerical* treatments on the one hand, and the *self-selection* treatment on the other hand. This means that we can reject the null hypothesis and accept hypothesis 2, that the correlation between self-assessed risk levels and investments in the risky investment fund is stronger when subjects choose themselves the information display format than when they do not. The statistical significance of this testing is also in line with all four OLS regressions (Appendix 4) where the dependent variable self_assessed_risk_level is a statistically significant factor of changes in the independent variable amount_to_invest, at the 5% significance level at least. These results from the OLS regressions are in line with the findings of Borsboom and Zeisberger (2020), that risk perception is a fundamental element of investment behavior with the ability to drive investment propensity.

5. Discussion

The aim of the thesis is to examine the impact of graphical and verbal/numerical representation of returns on investment propensity and risk perception and explore the relationships between some personal characteristics and investment decisions. With the experimental design and task, it was possible to measure the difference in the average investment amount between the graphical representation and the verbal/numerical representation both when participants were able to choose their preferred information display format and when they were not able to do so. This allowed for the examination of the impact of display format on investment behaviour. The role of providing people with the option to choose a display format themselves is examined as well, to see if people know, by observing their choice, what is better and more beneficial to them in order to optimize their investment decision. This is examined by testing whether the correlation of actual investment behaviour with self-assessed risk level is stronger in the *self-selection* treatment than in the other two treatments. For the analysis of this, the scale of self-assessed risk levels ranging between 0 and 7 is changed so that subjects could be categorized into each risk attitude, between risk averse, risk neutral, and risk seeking.

It is found that on average, varying the display format gives a higher investment amount for people receiving graphical representation, however, the differences are not significant. However, the correlation between actual investment behaviour with self-assessed risk levels is light positive and significant in both the *self-selection* treatment and the other two treatments. Moreover, risk perception regarding the risky investment fund was the same across the two display formats and for each treatment. Therefore, an inferential statement about the impact of the information display format cannot be provided. Analysis shows that for this experiment, there is no sufficient evidence to prove that investment decisions were driven by the display format used for communicating financial information. Also, it cannot be confirmed that the investment fund is perceived as less risky when information is presented *graphically* compared to the *verbal/numerical* treatment. However, results showing a higher investment amount in the *graphical* representation than in the *verbal/numerical* representation are supported by previous literature (Bateman et al., 2014; Linciano et al., 2018). In line with the findings of Bateman et al. (2014) who show that graphical representation leads to an increase in risk taking and in line with Linciano et al.'s (2018) arguments supporting that lower complexity reduces one's perceived riskiness by lowering the cognitive effort needed to process risk information, graphical representation in this study comes, on average, with higher amounts invested in the risky investment fund.

The fact that the results are not significant for hypothesis 1 testing could mean two things. On the one hand, it could be that the null hypothesis is true and hence, that there is no real effect of the display format on actual investment behaviour, possibly due to people paying more attention to the standard deviation as the measure of risk for their investment. On the other hand, hypothesis 1 may be true, but without sufficient supportive evidence to reject the null hypothesis. The possibility of arriving to non-significant results while hypothesis 1 is true may occur due to multiple reasons, such as the true effect size being too small, the variation in the data for each pairwise comparison being too high, and the size of the sample being too small (Visentin et al., 2020). These possible problems are also covered in the limitations section.

Moreover, main results from testing hypothesis 2 show a slight but statistically significant increase in the correlation of actual investment behaviour with self-assessed risk levels when participants have the option to choose an information display format compared to when they do not. This may indicate that it is actually helpful to deliver information about the risk and return characteristics of the same financial product using more than one representation format, as proposed by Diacon and Hasseldine (2007) and Linciano et al. (2018). As in Gurdal et al.'s (2017) study, actual investment behaviour is strongly predicted by the self-reported willingness to take risks. Further investigation of why there is stronger correlation between the investment amount and self-assessed risk levels when subjects choose themselves the information display format than when they do not would be definitely interesting, especially with an expansion of the framework addressed in the current thesis and under different circumstances that will allow for the external validity of the results.

6. Limitations

Acknowledging the potential limitations of this thesis is important as they may have an impact on the quality and external validity of the results. The external validity of the results refers to their application and generalization to a broader context with different settings than those of this study. The overrepresentation of young people aged 18-24, male participants, and people with an annual income lower than 25,000 euros may be a concern due to the possible impact of demographic variables on investment decisions or risk-taking attitude. For example, Charles and Kasilingam (2013) show that young investors tend to choose the same set of stocks rather than investing or trading on a variety of stocks. Also, despite the fact that the experimental task involved hypothetical money, a small investment for someone who has an annual income of more than 100,000 euros can be considered a big investment for someone who has an annual income of less than 25,000 euros and less wealth. The overrepresentation of people belonging to specific social groups within the population may, therefore, influence the quality as well as the external validity of the results.

Additionally, the effect estimates of the experimental design are influenced by differences on what people individually perceive as risk. Given the subjectiveness of risk perception (Vai et al., 2020) and that different people can pay attention to different things when evaluating risks (Holzmeister et al., 2020), the responses to Likert scales and the amounts invested could be arguably influenced as for some individuals the investment fund was risky while for others it was not risky at all. That is, one can distinguish low from high risk-taking behaviour using different investment amounts as seen in Table 12 in Appendix 1. This table from the data proves that some people believe that the investment fund is not risky at all while others believe that its' characteristics are extremely risky for investment, proving also the above argument regarding the subjectiveness of risk perception. The subjectiveness of each individual's judgment on how to assess risks can be a limitation for the assumption in favour of the expected pattern according to which risk averse people should invest on average less money in the risky investment fund than people with a higher risk tolerance. The fact that a particular investment's level of risk may be interpreted differently across people may affect to some extent the accuracy of the result. This is because the amount of money each subject decides to invest in the risky investment fund is expected to reflect their risk profile, but under the assumption that all participants think that the investment fund is riskier than the alternative choice of the risk-free asset. Thus, concerning self-assessed risk behaviour levels, perceived risk, and investment amounts, it needs to be acknowledged that there is no consensus as to the numerical thresholds that should exist in order to distinguish and have a clear unanimous agreement of what is low and what is high risk.

7. Conclusion

Taking into account the influence of different presentation formats on decision-making, and given the impact of numerous behavioural biases on investment judgments even among finance professionals (Baker et al., 2017), this research examines whether the mode of information processing, visual or verbal, impacts the financial decisions and risk perception of investors. Using an experimental design that varies the information presentation formats between two presentation methods, this paper extends the existing literature by analysing the relationship between investment propensity and self-assessed risk levels under different circumstances. These circumstances change with variations in the display formats used to disclose financial information and also upon having or not having the option to choose for a preferred representation of returns before the investment decision. Although varying the information display format from verbal/numerical representation to graphical representation comes with a slight increase in investment propensity in this thesis' experiment, this impact is not statistically significant. Furthermore, when there is the option for people to choose themselves the presentation format, there is a higher correlation with self-assessed risk levels and investments in the risky investment fund than the case of subjects being randomly assigned into one of the two display formats.

With regard to policy, this could be for example a reason for fund managers and financial advisors to further investigate the possibility of making more than one display formats available when disclosing financial information to clients prior to their investment decisions as suggested by Diacon and Hasseldine (2007) and Linciano et al. (2018), for a clearer image and understanding of all risks involved with the investment.

Still, the best way for presenting the risk and return characteristics of financial products is a debatable issue (Anic and Wallmeier, 2020). Further research on the topic of presentation formats and their impact on investors' behaviour could raise important implications for the demands of financial regulators and their criteria regarding information display formats, what and how it needs to be presented to investors. This could ultimately lead to improvements in information documents for investors like the EU regulation required "Key Information Document".

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Appendix 1:

Table 6: Summary statistics for variable age range

Age Range	Freq.	Percent
(1) 18-24	123	50.82
(2) 25-34	75	30.99
(3) 35-44	15	6.20
(4) 45-55	18	7.44
(5) 56-65	9	3.72
(6) 66 or older	2	0.83
Total	242	100

Table 7: Summary statistics for variable gender

Gender	Freq.	Percent
(1) Male	168	69.42
(2) Female	69	28.51
(3) Non-binary	4	1.65
(4) Prefer not to say	1	0.42
Total	242	100

Table 8: Summary statistics for variable education

Education	Freq.	Percent
(1) No schooling completed	1	0.42
(2) High school graduate	42	17.35
(3) Bachelor’s degree	104	42.98
(4) Master’s degree	92	38.02
(5) Doctorate degree	3	1.23
Total	242	100

Table 9: Summary statistics for variable income

Income	Freq.	Percent
(1) Less than 25,000 euros	132	54.54
(2) 25,000 – 50,000 euros	52	21.49
(3) 50,000 – 100,000 euros	17	7.03
(4) 100,000 – 200,000 euros	10	4.13

(5) Prefer not to say	31	12.81
Total	242	100

Table 10: Summary statistics for dummy variable finance_field

Finance_field	Freq.	Percent
(1) Yes	95	39.26
(2) No	147	60.74
Total	242	100

Table 11: *Summary statistics for variable financial_literacy.*

Financial Literacy	Freq.	Percent
0	25	10.3%
1	38	15.7%
2	49	20.2%
3	130	53.7%
Total	242	100.00%

Table 12: *Summary statistics for variable investment_fund_a_risk.*

Investment_fund_a_risk	Freq.	Percent
0	12	4.96%
1	12	4.96%
2	31	12.81%
3	57	23.55%
4	73	30.17%
5	42	17.36%
6	12	4.96%
7	3	1.24%
Total	242	100.00%

Appendix 2:

Page 1

Dear Participant. Welcome to the experiment. This research project is being conducted as part of a Master's thesis by Panayiotis Pantelides at Erasmus University Rotterdam.

Your participation in this research is voluntary and will take approximately 5-10 minutes. Your response will remain confidential and identifying information such as your name, email address or IP address will not be collected. For any questions, you can contact: 602794pp@student.eur.nl

By proceeding to the next page, you thereby consent to participate in the online survey.

Page 2 – Graphical treatment

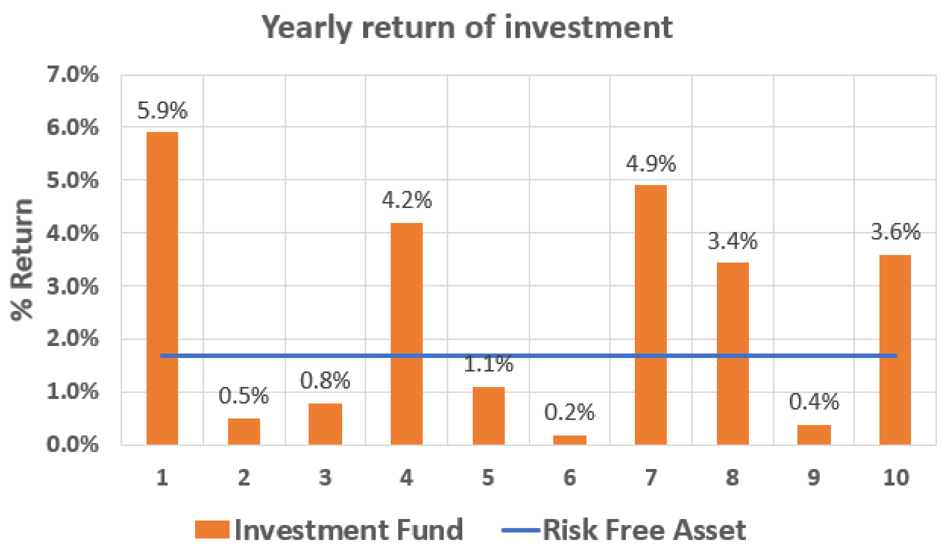
Suppose that you want to invest 5000 euros and you need to decide how to allocate that amount between a **risky investment fund** and a **risk-free asset**. Before you decide, you are going to be presented with graphical information regarding the annual rate of returns of the **investment fund** and the **risk-free asset**.

Please read the following information carefully.

The final outcome of your investment is calculated as follows:

- If you invest Y euros in the **risky investment fund** you will get back Y **PLUS** a randomly drawn return out of the return distribution shown below (ranging from **0.2%** to **5.9%** of Y). The rest (X euros) will be invested in the **risk-free asset** and will give you back X euros **PLUS 1.7%** of X.

- Assuming that you will invest X euros in the **risk-free asset** and Y euros (5000-X) in the **risky investment fund**, the formula for your investment's final outcome is the following:
  Outcome of Investment = (X+1.7% of X) + (Y+random% of Y).



Page 2 – Verbal/numerical treatment

Suppose that you want to invest 5000 euros and you need to decide how to allocate that amount between a **risky investment fund** and a **risk-free asset**. Before you decide, you are going to be presented with numerical(verbal) information regarding the annual rate of returns of the **investment fund** and the **risk-free asset**.

Please read the following information carefully.

The final outcome of your investment is calculated as follows:

- If you invest Y euros in the **risky investment fund** you will get back Y **PLUS** a randomly drawn return out of the return distribution described below (ranging from **0.2%** to **5.9%** of Y). The rest (X euros) will be invested in the **risk-free asset** and will give you back X euros **PLUS 1.7%** of X.

- Assuming that you will invest X euros in the **risk-free asset** and Y euros (5000-X) in the **risky investment fund**, the formula for your investment's final outcome is the following:
Outcome of Investment = (X+1.7% of X) + (Y+random% of Y).

- The **risk-free asset** gives a return of 1.7% for sure.

- The **risky investment fund** gives an expected return of 2.5%. However, the returns of the risky investment fund are characterized by fluctuations:

- This means, possible returns are **as low as 0.2%** and **as high as 5.9%**, and other values in between:

- The **expected return** is 2.5%, meaning that **the average of all returns** that are displayed is 2.5%.

- The **maximum return** you receive for the risky investment fund is 5.9%.
- The **minimum return** you receive for the risky investment fund is 0.2%.

- For the **other returns within those boundaries**, there are some examples on the likelihood of various returns: **68% of the returns** can lie between 0.37% and 4.63%, **95% of the returns** can lie between -1.76% and 6.76%, and **99.7% of the returns** can lie between -3.89% and 8.89%.

Page 2 – Self selection treatment

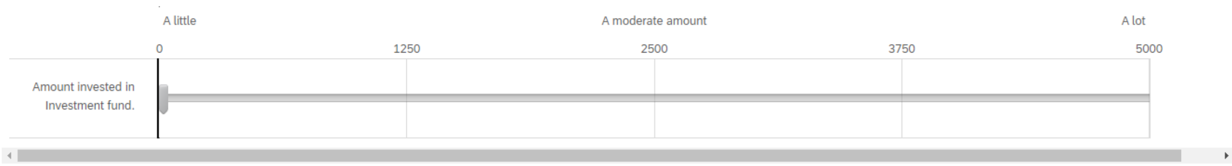
Shortly, you are going to enter a scenario where you will be asked to invest and allocate a hypothetical endowment, choosing between a **risky Investment fund** and a **risk-free asset**. Here, you have the chance to choose between receiving
either **graphical** or **numerical(verbal)** information regarding the expected returns and risks connected to these two financial products.

Please choose the type of information you wish to receive:

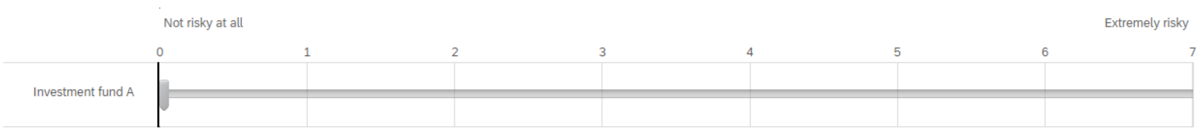
Graphical

Numerical

How much of your endowment would you invest in the **risky investment fund**? Please note that the rest of this amount is going to be invested in the **risk-free asset**.



On a 7-point scale, how risky do you think the investment fund is?



How well did you understand the instructions given to you?

Page 3 – Risk level and financial literacy elicitation

How do you rate your risk-taking behaviour?

Appendix 3:

Table 12

financial_literacy	Freq.	Mean	Std. Dev.	Min	Max
0	25	2419	721	1190	4000
1	38	2376	871	1090	5000
2	49	2397	945	611	5000
3	130	2601	1337	0	5000
Total	**242**	**2506**	**1146**	**0**	**5000**

Summary statistics for variable financial_literacy depending on amount_to_invest.

Table 13

Age_range	Mean of amount_to_invest	Mean of investment_fund_a_risk	Mean of risk_behaviour	Freq.
18-24	2,235	3.439	3.63	123
25-34	2,871	3.440	4.09	75

35-44	2,669	3.200	3.67	15
45-55	2,688	4.111	3.72	18
56-65	2,618	3.556	3.44	9
66 or older	2,072	2.500	3.00	2
Total	**2,506**	**3.471**	**3.77**	**242**

Summary statistics for variable age_range depending on variables amount_to_invest, investment_fund_a_risk, and risk_behaviour.

Table 14

Annual_income_range	Mean of amount_to_invest	Mean of investment_fund_a_risk	Mean of risk_behaviour	Freq.
Less than 25,000 euros.	2,325	3.545	3.63	132
50,000 – 100,000 euros.	2,770	3.519	4.17	52
50,000 – 100,000 euros.	3,068	2.765	3.47	17
100,000 – 200,000 euros.	2,573	3.100	3.60	10
Prefer not to say.	2,500	3.581	3.90	31
Total	**2,506**	**3.471**	**3.77**	**242**

Summary statistics for variable annual_income_range depending on variables amount_to_invest, investment_fund_a_risk, and risk_behaviour.

Table 15

Education_lvl	Mean of amount_to_invest	Mean of investment_fund_a_risk	Mean of risk_behaviour	Freq.
No schooling completed.	2,503	2.000	3.00	1

High school graduate	2,415	3.262	3.67	42
Bachelor’s degree	2,358	3.529	3.64	104
Master’s degree	2,653	3.446	3.88	92
Doctorate degree	4,373	5.667	6.33	3
Total	**2,506**	**3.471**	**3.77**	**242**

Summary statistics for variable education_lvl depending on variables amount_to_invest, investment_fund_a_risk, and risk_behaviour.

Appendix 4:

Table 16: OLS regression for graphical vs numerical representation in treatment self-selection.

	amount to invest		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	3301.96	1644.23 – 4959.69	**<0.001**
financial_literacy	91.82	-180.44 – 364.07	0.503
option [Numerical]	-465.61	-978.80 – 47.57	0.075
perceived_riskiness	-360.57	-517.78 – -203.36	**<0.001**
instructions_understanding	-17.10	-119.24 – 85.04	0.739
self_assessed_risk_level	142.94	1.32 – 284.56	**0.048**
age_range [25-34]	1210.55	624.58 – 1796.51	**<0.001**
age_range [35-44]	424.48	-593.57 – 1442.54	0.408
age_range [45-55]	174.84	-1028.79 – 1378.46	0.772
age_range [56-65]	367.23	-752.20 – 1486.67	0.514

age_range [66 or older]	2797.91	-162.14 – 5757.96	0.063
gender [Male]	63.54	-475.52 – 602.60	0.814
gender [Non-binary]	-1893.26	-4202.83 – 416.31	0.106
education_lvl [Doctorate degree]	2404.55	271.16 – 4537.95	**0.028**
education_lvl [High school graduate]	-0.16	-715.33 – 715.01	1.000
education_lvl [Master's degree]	-227.27	-814.46 – 359.93	0.442
annual_income_range [25,000 - 50,000 euros.]	519.27	-486.19 – 1524.74	0.306
annual_income_range [50,000 - 100,000 euros.]	186.35	-984.78 – 1357.48	0.751
annual_income_range [Less than 25,000 euros.]	-692.01	-1720.72 – 336.70	0.183
annual_income_range [Prefer not to say.]	-4.21	-1221.49 – 1213.07	0.995
finance_field [Yes]	-318.30	-833.00 – 196.39	0.221
Observations	81		
R^2 / R^2 adjusted	0.655 / 0.540		

Table 17: OLS regression for graphical vs numerical representation in treatment graphical and treatment numerical.

	amount to invest		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	1835.36	474.72 – 3196.00	**0.009**
financial_literacy	-87.20	-265.57 – 91.17	0.335
option [Numerical]	-207.21	-550.19 – 135.76	0.234
perceived_riskiness	-140.65	-259.14 – -22.17	**0.020**
instructions_understanding	47.44	-36.79 – 131.67	0.267

self_assessed_risk_level	238.20	111.79 – 364.61	**<0.001**
age_range [25-34]	140.70	-261.63 – 543.03	0.490
age_range [35-44]	251.63	-595.50 – 1098.77	0.558
age_range [45-55]	149.71	-587.27 – 886.68	0.689
age_range [56-65]	-305.07	-1455.13 – 844.99	0.601
age_range [66 or older]	-1228.88	-3603.89 – 1146.14	0.308
gender [Male]	-209.37	-623.19 – 204.45	0.319
gender [Non-binary]	-2.05	-1534.11 – 1530.01	0.998
gender [Prefer not to say]	2025.04	-167.97 – 4218.05	0.070
education_lvl [Doctorate degree]	1532.15	-100.29 – 3164.59	0.066
education_lvl [High school graduate]	-54.48	-533.00 – 424.05	0.822
education_lvl [Master's degree]	-12.81	-437.52 – 411.89	0.953
education_lvl [No schooling completed]	-184.07	-2341.35 – 1973.20	0.866
annual_income_range [25,000 - 50,000 euros.]	96.83	-1047.28 – 1240.94	0.867
annual_income_range [50,000 - 100,000 euros.]	979.96	-358.59 – 2318.51	0.150
annual_income_range [Less than 25,000 euros.]	238.74	-882.53 – 1360.01	0.674
annual_income_range [Prefer not to say.]	71.93	-1131.38 – 1275.25	0.906
finance_field [Yes]	10.27	-359.85 – 380.39	0.956
Observations	161		
R^2 / R^2 adjusted	0.214 / 0.089		

Table 18: OLS regression for graphical vs graphical representation in treatment graphical and treatment self-selection.

	amount to invest		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	1590.42	217.74 – 2963.11	**0.024**
financial_literacy	8.10	-205.57 – 221.77	0.940
self_selection [YES]	41.39	-335.39 – 418.17	0.828
perceived_riskiness	-227.00	-347.49 – -106.50	**<0.001**
instructions_understanding	38.06	-49.38 – 125.49	0.391
self_assessed_risk_level	210.44	82.55 – 338.33	**0.001**
age_range [25-34]	354.91	-117.57 – 827.39	0.140
age_range [35-44]	658.72	-204.24 – 1521.68	0.133
age_range [45-55]	538.09	-221.86 – 1298.05	0.164
age_range [56-65]	46.50	-997.71 – 1090.70	0.930
age_range [66 or older]	-190.07	-2009.18 – 1629.04	0.836
gender [Male]	-172.63	-599.80 – 254.54	0.425
gender [Non-binary]	262.21	-1146.43 – 1670.86	0.713
gender [Prefer not to say]	2252.73	23.47 – 4481.99	**0.048**
education_lvl [Doctorate degree]	1478.63	-164.92 – 3122.18	0.077
education_lvl [High school graduate]	-167.30	-690.09 – 355.49	0.528
education_lvl [Master's degree]	-302.74	-754.89 – 149.41	0.187
annual_income_range [25,000 - 50,000 euros.]	460.80	-552.66 – 1474.26	0.370
annual_income_range [50,000 - 100,000 euros.]	1700.81	449.05 – 2952.56	**0.008**
annual_income_range [Less than 25,000 euros.]	603.59	-426.72 – 1633.90	0.248

annual_income_range [Prefer not to say.]	794.06	-304.17 – 1892.29	0.155
finance_field [Yes]	171.74	-229.39 – 572.88	0.398
Observations	142		
R^2 / R^2 adjusted	0.292 / 0.168		

Table 19: OLS regression for numerical vs numerical representation in treatment numerical and treatment self-selection.

	amount to invest		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	2949.36	1348.73 – 4550.00	**<0.001**
financial_literacy	-79.57	-309.08 – 149.93	0.492
self_selection [YES]	-28.65	-519.94 – 462.65	0.908
perceived_riskiness	-207.35	-376.49 – -38.21	**0.017**
instructions_understanding	7.94	-104.93 – 120.81	0.889
self_assessed_risk_level	256.91	106.49 – 407.34	**0.001**
age_range [25-34]	784.21	273.12 – 1295.29	**0.003**
age_range [35-44]	118.05	-996.91 – 1233.00	0.834
age_range [45-55]	-760.44	-2044.18 – 523.29	0.242
age_range [56-65]	81.46	-1251.97 – 1414.90	0.904
gender [Male]	-425.26	-977.11 – 126.58	0.129
gender [Non-binary]	-2683.06	-5106.23 – -259.90	**0.030**
education_lvl [Doctorate degree]	2290.74	-11.81 – 4593.29	0.051
education_lvl [High school graduate]	-127.85	-838.39 – 582.69	0.721
education_lvl [Master's degree]	228.34	-342.65 – 799.33	0.428
education_lvl [No schooling completed]	716.16	-1682.81 – 3115.12	0.554

annual_income_range [25,000 - 50,000 euros.]	-311.31	-1539.15 – 916.54	0.615
annual_income_range [50,000 - 100,000 euros.]	-72.18	-1365.13 – 1220.78	0.912
annual_income_range [Less than 25,000 euros.]	-797.80	-2026.20 – 430.59	0.200
annual_income_range [Prefer not to say.]	-837.57	-2231.69 – 556.55	0.235
finance_field [Yes]	-276.18	-763.43 – 211.06	0.263
Observations	100		
R^2 / R^2 adjusted	0.441 / 0.299		