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Combining cognition and economics: The effect of visual attention on investment decisions.

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Abstract

This paper analyses the effect of visual attention on perceived risk, expected return, and willingness to invest. Conventionally, standard deviation of returns is seen as *the* measure for risk. However, more recently other salient features such as highs, lows, and probability of a loss have been shown to influence perceived risk. Apparently, investors are influenced by some visual factors of price paths. This paper studies the channel through which certain factors may influence invest decisions, namely visual attention. The effect of visual attention is tested experimentally by creating two treatments, one with short visual attention (2 seconds) and one with long visual attention (10 seconds). The findings suggest that visual attention can influence perceived risk and expected return considerably. No such effect was found for willingness to invest. This indicates that not only graphical features, but also the visual attention that is associated with them are relevant when making investment decisions.

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1. Introduction

How do investors determine which stocks are of interest to them? Do their decisions follow a stochastic process, and therefore not influence prices? Or do investors make conscious choices? Barber and Odean (2008) argue that investors simply buy stocks that capture their attention. This, however, not only depends on how attention grabbing the stock is. It also depends on how much attention the investor pays to the decision. It is both an external and internal process.

Price paths are often used to study patterns and to forecast future changes in stock prices (Fama, 1995). Despite the limited information that is presented in such price paths, they are often used to analyse investment decisions (Malkiel and McCue, 1985). According to Nolte and Schneider (2018), this is explained by the fact that price paths form the main source of the limited graphical information available.

How price charts are interpreted, is a matter of perception. The question arises how investors perceive such charts and what information is valuable. This is problematic, since providers of financial assets can cherry pick the information that is presented in them, thereby influencing the readers of the charts. For this reason, many studies have been conducted on how certain metrics affect risk perception. For example, Diacon and Hasseldine (2007) showed that the format in which information is presented significantly influences risk perception. In this context, providing return information as percentage yield versus fund value affected how subjects make investment decisions. Additionally, Huber and Huber (2018) showed in a similar way that price scale set-up influences perception. Borsboom and Zeisberger (2020) found that return and standard deviation are insufficient in illustrating risk perception. Instead, more salient features such as highs and lows are better predictors of perceived risk. This further confirms that investors pay attention to features that stand out. For these reasons, different factors that influence perception of price charts have been studied to a great extent.

However, the channel through which these metrics affect risk perception have not been studied to the same extent. As mentioned previously, the attention that a stock grabs is both an internal and external process. Investors may not always be very analytical; visual and cognitive attention are not always optimal. Instead, information may be used to proxy for attractiveness quickly and easily. To that end, the amount of attention that is paid to price charts may influence investment decisions. Time of exposure could therefore be a variable affecting the behaviour of investors as a result of differences in visual attention.

This leads to the following research question*: 'What is the effect of visual attention on investment decisions?'*

An online survey is conducted to examine the effect of visual attention on investment behaviour. Two treatments are created to isolate the effect visual attention. One treatment group has a short time

window to make investment decisions. The other group was given a longer time window to make the same decisions; activating more cognitive processes by prolonging visual attention and exposure to the charts. Participants are randomly divided among the two treatments and answer questions on perceived risk, expected return and their willingness to invest. Standard deviation and return information are not given, to eliminate other variables that may affect decision making.

Irregular moving price paths are used, as real price paths often display such irregular movements. It has been demonstrated that irregular price movements result in different investment decisions (Pincus & Kalman, 2004); risk is often perceived to be higher than in stylized price paths. Since actual price developments are often irregular, and irregular movements influence decisions, it adds realism to use irregular moving price paths.

This paper adds to existing literature on price charts and framing, yet adds the new consideration that the channel (visual attention versus cognition) plays an important role in determining investment decisions.

The paper is structured as follows: the literature review gives an overview of the existing literature on framing and elaborates on cognitive systems. The hypotheses are drawn from the literature. The experimental design is explained under methodology. The statistical test results are explained in the results section. After that, conclusions are drawn based on the results. Finally, the paper concludes with a discussion section that illustrates the strengths and weakness of the methodology and the results.

2. Literature Review

According to typical finance theory, standard deviation of returns is commonly used as a measure of risk (Markowitz, 1952). However, more recent evidence suggests that more salient factors may be better predictors of risk perception. For example, Zeisberger (2018) and Holzmeister et al (2019) used price charts with various salient risk measures. They find that probability of loss is a good predictor of risk perception. Maximum loss as well as loss probability are positively and significantly correlated with perceived risk. These salient factors are better predictors for perceived risk, because standard deviation and expected return are not always easy to understand visually. When subjects were asked to make decisions on different return distributions that had the same expected return and same standard deviation, they showed inconsistent preferences, even though according to typical financial theory, that should not be the case. Instead, other measures are used because they are easier to understand graphically. When subjects can direct more attention to return distributions, it becomes easier to pay attention to more salient features and they make different judgements as a result.

Additionally, investors are often buyers of attention. Stocks that see high coverage in the news, stocks that have remarkable information, stocks that have high abnormal trading volume or stocks with large one day abnormal returns stand out (Barber & Odean, 2008). This buying behaviour results from the overwhelming amount of stocks investors can choose from. Only in the U.S. there are more than 7000 common stocks that investors can choose from. Investors are boundedly rational and can therefore not process all available information to form the optimal choice. Instead, they resort to more time efficient measures and focus on those stocks that grab attention. As investors are buyers of attention, it begs the question how their own attention plays a role in determining which stocks to buy.

Literature on advertising gives useful insight. Many studies have been conducted to assess the effect of attention on the effectiveness of advertisements. This is the case for consumer products, but also investments. For example, the visual attention given to commercials is positively correlated with advertising effectiveness (Jeong, 2007). Furthermore, length of the advertisements is also of influence. Longer length is associated with more effective advertising, however, if the length is too long, advertisements length is negatively linked to memorability and persuasiveness because consumers are overwhelmed by the amount of camera shots (MacLachlan & Logan, 1993).

Consumer psychology has shown that thought processes are supplemented by metacognitive experiences, for example how easy or difficult it is to bring certain information to mind (Schwarz, 2004). Further influence has the ease and speed with which newly presented information can be processed: processing fluency. This may have important implications for investments, as memorability and especially persuasiveness could heavily influence attractiveness of investments and thereby the investment decisions. Processing fluency can be affected by many factors. Some factors affect precision and speed of processes concerned with the recognition of a stimulus' physical structure. In other words, they affect perceptual fluency (Jacoby, Kelley & Dywan, 1989). Concrete variables are the clarity of a stimulus, or the duration of the presented stimuli. Both are relevant for this paper. As a result of these metacognitive experiences, decisions of individuals are often different than expected. This is true because metacognitive experiences are informative and are drawn on to form decisions. To illustrate: Menon & Raghubir (2003) and Wänke, Bohner & Jurowitsch (1997) showed that consumers like products less when more positive aspects could be thought of. Moreover, such options were likely to be deferred. These findings are unexplained by content centred decision models. Instead, personal metacognitive experiences appear to influence judgement through processing fluency.

Visual expectations and attention

Many theories aim to explain the framing effect. In general, these theories are divided into three categories: formal, motivational, and cognitive theories (Kühberger, 1998). This section focusses on the

latter category. Cognitive theories' purpose is to explain the underlying cognitive processes involved in decision making.

The limiting factor in visual cognition is the brain, the brain's computational capacity is not large enough to process all incoming information. Only a small part of the entire visual sensory system can be processed. This becomes even more evident when the information entering the visual system is ambiguous. Two mechanisms are important for processing visual information: 'attention prioritizes stimulus processing based on motivational relevance' (attention) and 'expectations constrain visual interpretation based on prior likelihood' (expectations) (Summerfield & Egner, 2009).

Both visual expectations and visual attention aid visual perception of the brain. However, they do it in different ways. Visual expectations assist perception by limiting the options of interpretation, based on past likelihood. For example, certain pieces of furniture would be recognized sooner in the setting of a room then they would be in a park. This is explained by the brain having formed expectations based on previous observations. Visual attention, on the other hand, helps the brain focus on processing of information that is judged to be the most important (Tsotsos, 1997).

Essentially, visual attention works because it is the visual stimuli which is excluded from visual expectations. Therefore, such stimuli stand out. However, visual expectations and attention often interact in practice. To illustrate, known perceptual context formed through expectations allows visual attention to be directed to the most relevant information in that situation. In an investment context, this could mean that sophisticated investors can easier detect price movements that are out of the ordinary and therefore trade more on such features.

Both visual expectations and visual attention are relevant for this study. Investors (consciously or unconsciously) use expectations when interpreting visual return distributions. More interesting is visual attention. This is the exogenous process that directs attention towards visual stimuli which are highly salient (Yantis & Jonides, 1990). In other words, this is what makes investors focus on stand out features in the price paths.

Cognition

Gonzalez et al (2015) conducted one of the few studies that make use of brain activation functional magnetic resonance (fMRI) to examine how cognitive information processing principles contribute to the theory of framing. They state that individuals choose between alternatives based on the amount of cognitive effort required. That is, individuals aim to make the best choice while using minimal cognitive exertion. Moreover, this work demonstrated that the amount of cognitive effort that is required to choose a certain gain is significantly lower than the effort required to select a risky gain. For losses, on the other hand, the effort was comparable for both scenarios. Hirshleifer (2001) found similar correlations in an

actual investment setting. Additionally, Gonzalez et al (2015) demonstrated (using fMRI) that the parietal cortex and the prefrontal cortex are predominantly important in making investment decisions implying that imagery and working memory are likely to be involved in the decision making process.

Fuzzy-trace theory

Fuzzy-trace theory (FTT) states that individuals dramatically oversimplify information when confronted with difficult choices (Reyna, & Brainerd, 1991). Consider the Asian disease problem for example. Participants must imagine a disease that may kill 600 people. The participants have the choice to either save 200 people for sure, or to take a risk where there is a 1/3 probability that all 600 people are saved, but a 2/3 probability that no one will be saved. In the second scenario, the choices are framed as the probability or certainty to kill people. In other words, the choices remain the same, but the frame is now negative. According to FTT, participants are likely to act based on the simplest gist. In the case of the Asian disease problem, participants simply prefer the notion of saving people over the possibility of not saving anyone in the positive frame. Contrarily, the notion to kill people in the negative frame is worse than the small possibility to not kill anyone. This illustrates that cognitive processes indeed prioritize taking action based on the simplest gist and results becomes secondary, implying that individuals unconsciously simplify decisions to decrease cognitive effort.

In fact, cognitive cost-benefit trade-off theory explains that choice is a compromise between the want to minimize the amount of cognitive effort, while making the optimal decision. According to this theory, individuals first attempt to make an optimal decision with simple options that is satisfactory. Only when this simpler approach is not satisfying, will an individual expand more cognitive effort to generate a better alternative (Payne et al., 1993).

Hypotheses

Nolte and Schneider (2018) and Grosshans and Zeisberger (2018) explored the influence of distinctive price path features on how investors perceive attractiveness of the investment. For example, they studied the effect of up-down versus down-up sequences and found significantly different satisfaction levels and perceived risk. This paper investigates whether investors display different behaviour when visual attention changes. In other words, if investors are exposed to distributions for a shorter time, only visual attention will be a tool to judge the attractiveness of the distribution. When exposed to the distributions for a longer time, more cognitive processes help to form a decision.

As investors are expected to minimize cognitive effort as much as possible, and dramatically oversimplify while forming their decisions, it is hypothesized that shorter visual attention will lead to

decreased perceived risk. In other words, increasing visual attention is expected to positively influence perceived risk. As higher risk is associated with higher return, the expected sign for return expectations is hypothesized to be positive as well. Lastly, willingness to invest is expected be influenced negatively, as it is generally less likely that investors would want to invest when more uncertainty is associated with an investment.

The following hypotheses are formulated to test the theory:

1) H_0: Visual attention has no effect on perceived risk.
   H_a: Visual attention has a positive effect on perceived risk.

2) H_0: Visual attention has no effect on return expectations.
   H_a: Visual attention has a positive effect on return expectations.

3) H_0: Visual attention has no effect on willingness to invest.
   H_a: Visual attention has a negative effect on willingness to invest.

3. Methodology

Method and subjects

The experiment was designed in the form of an online survey. This poses several advantages and disadvantages. First off, an obvious advantage is the reach. Online experiments allow for a larger reach, making it easier to generate the desired data. The trade-off, however, is that participants were not supervised. Secondly, the survey is prone to response bias. The response bias is a serious potential methodological problem that leads to an unrepresentable sample (Paulhus, 1991). As the survey fundamentally depends on different time frames for the treatment groups, it may be that participants with a low attention span quit mid-way through the survey disproportionally often in the long treatment.

Due to limited (financial) resources, the process of response collection was mainly dependent on personal reach. There was no financial incentivization, to not influence participants responses. Since it was difficult to generate responses, a large share of responses was generated in two high schools: Candea College (Duiven, The Netherlands) and Etty Hillesum Lyceum (Deventer, The Netherlands). This means that the sample is over-represented by teenagers. The survey asked relatively sophisticated questions and therefore it would have been preferable that the mean age was higher. On the positive side, however, the sample is relatively homogenous and therefore more comparable. Of note, the survey was conducted by students during class, implying that these participants were likely more concentrated and focussed than participants who filled in the survey in their free time.

222 responses were collected, of which 157 responses were usable across the two treatments. 76 participants were allocated to the long treatment (10 seconds), and 81 participants were allocated to the short treatment (2 seconds). 49% of the sample was male and 51% of the sample was female. The mean age of the sample was 20, explained by the overrepresentation of teenagers in the sample. The total combined amount of observations for male and female does not total to 157, for participants were allowed to not fill in the gender question. The same was true for age. This likely pushed the mean age down further. Table 1 shows the characteristics of the participant in the two treatments.

Table 1: Respondent characteristics per treatment.

Treatment	Age			Male	Female
	Avg.	Min.	Max.		
1: Short	21.41	13	63	37	39
2: Long	18.35	13	58	32	32
Total				69	71

Experimental design

The experiment was a between subject design. In a between subject design, subjects do not know what the treatment variable is, and future answers were not influenced by past answers. The treatment variable was visual attention. To manipulate this variable, there was either a short or long time window to make decisions. The short treatment had 2 seconds to look at the price charts and was then asked to make decisions, whereas the long treatment had 10 seconds to look at the price charts before making a decision. Little to no research could be identified to help determine the time windows, meaning the time windows are somewhat arbitrarily chosen. Trial and error helped to determine that the short time-window needed to be extremely short, so that the subjects had no time to use cognitive processes to form decisions. Five seconds seemed a short window but allowed for too much cognitive thinking. Two seconds was the best short option that allowed for perceiving the charts, but not having the ability to analyse them. The long treatment needed to be sufficiently long to ensure a more cognitive process to study the charts, while simultaneously not being too long to demotivate participants. Ten seconds was a good middle ground. The investment decisions were displayed on the screen after the chart, to ensure that the participants only had the limited amount of time to look at the price charts. This was explained clearly in the introduction section (appendix A). There was no time limit to fill in the answer.

For every chart, the participant randomly answered one of the following investment questions: 1. ‘Please indicate on a (Likert) scale from 1-7 how risky you perceived the investment to be’. 2. ‘Please indicate on a (Likert) scale from 1-7 what you expect the return to be’. And 3. ‘Please indicate on a (Likert) scale from 1-7 how willing to invest you are’ (see appendix B for an example of a question). Although answering all three questions for every chart would increase the dataset, it could possibly influence the answers to the proceeding questions and significantly elongate the experiment. Hence, it

was decided to only ask one question for each chart. The Likert scale is used as it is an universal ways of collecting data through surveys, making it easy to understand and allowing unsophisticated subjects to provide relevant answers. Additionally, it guarantees consistency throughout the entire survey. Likert scale data is ordinal, allowing for relevant statistical testing. The downside of the Likert scale is that the scale is not continuous, and therefore makes it impossible to measure attitudes perfectly. However, the simplicity and statistical advantages justifies the use of the Likert scale.

All participants were provided with three test questions prior to starting the actual experiment, to familiarize them with the survey. The order of both the charts and the questions was randomized to eliminate ordering effects. The test questions were not randomized, to ensure that participants did not answer the same investment question twice. Instead, participants answered each investment question once in the test questions section. The actual experiment was composed of 15 questions, being divisible by three to ensure that all investment questions were represented equally.

Many different charts were used to eliminate the effect of certain price path shapes (see appendix C for all price paths). The price charts are based on US stock data (2017) and taken from the Centre for Research in Security Prices (CRSP) by the Wharton Research Data Services. It is the standard for US security data. The charts are categorized into 4 categories: ‘down-up’, ‘neutral’, ‘up-down’, and ‘crash’. These categories are again divided into steady and non-steady. The two treatments saw the same fifteen charts. Therefore, there should be no systematic difference between the average answers provided between the two treatments.

The next page provides a graphical overview of the different charts that were presented to the participants. The time horizon was 1 year for all the charts, no additional information (such as company name, number of employees, industry, etc.) was provided to keep the design as simple as possible and to accurately assess the effect of the variance in time windows.

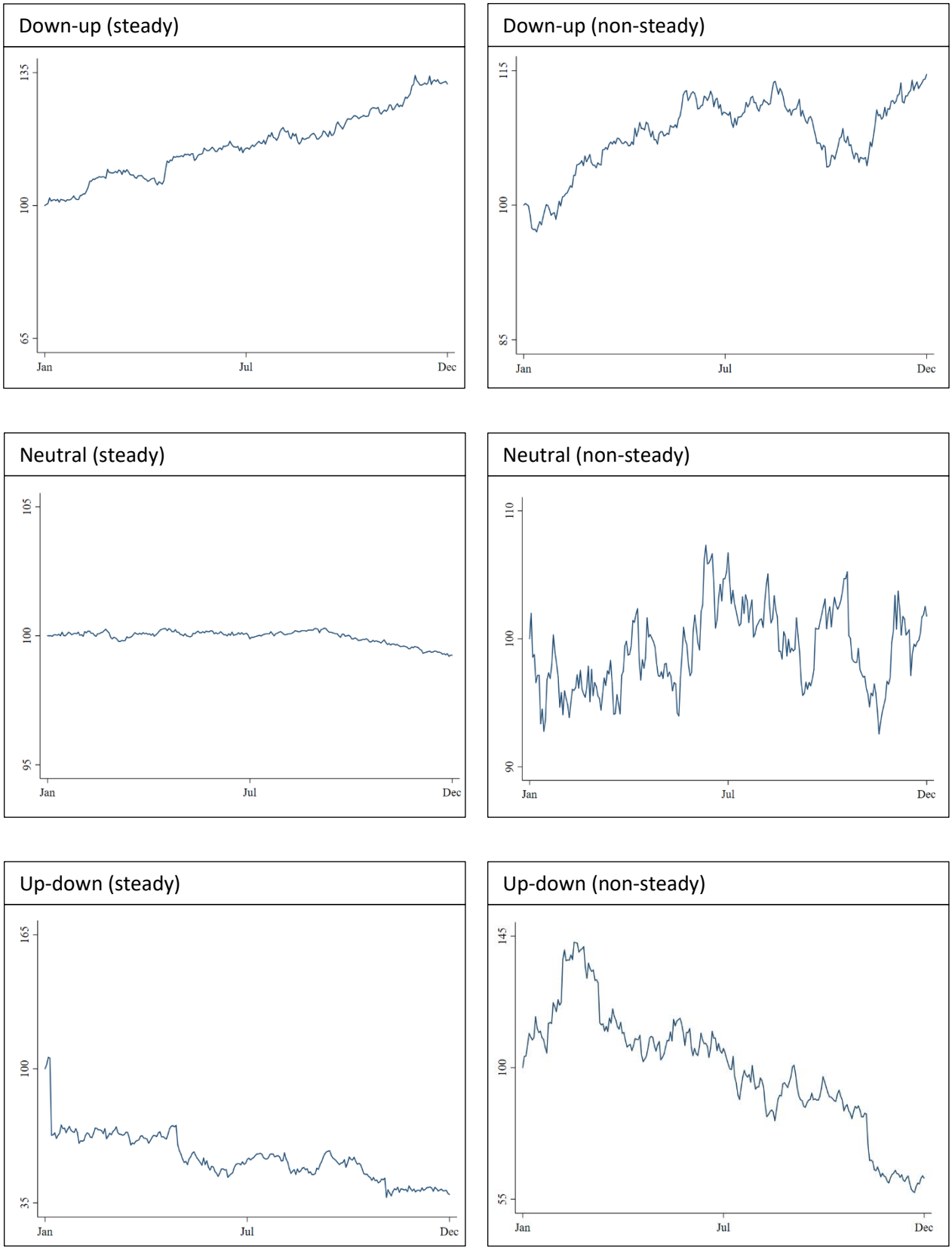
Proceeding the dependent variable questions (the investment decisions), participants answered three simple financial literacy questions for robustness (appendix D). They can be used to determine the importance of financial understanding on the results. Additional basic questions are used as controls, they include: knowledge; rate your knowledge on investment; Ordinal, 1 = lowest 7 = highest, risk taking; how willing are you to take financial risk; Ordinal, 1 = lowest 7 = highest, understanding: how well did you understand the experiment; Ordinal, 1 = lowest 7 = highest, and participants were asked to indicate how they would have benefited from having more time to see the price charts; Ordinal, 1 = lowest 7 = highest.

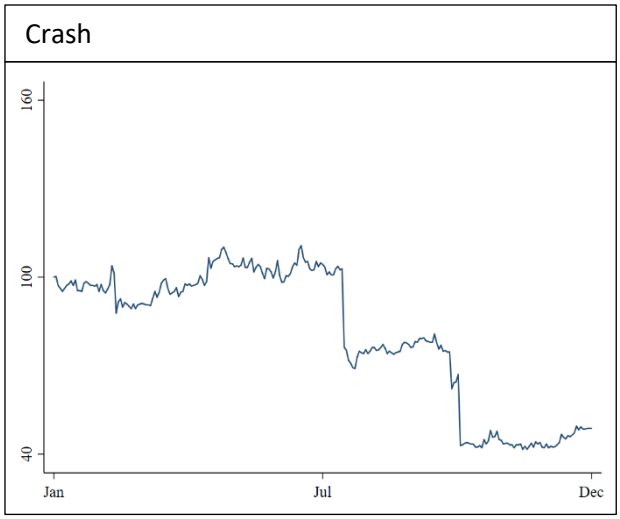
Figure 1 provides an overview of the price paths that the participants saw in the experiment. For each category previously described, there are two real examples that were in the survey. One steady, and one non-steady. All different price paths that were used in the experiment can be found in appendix C.

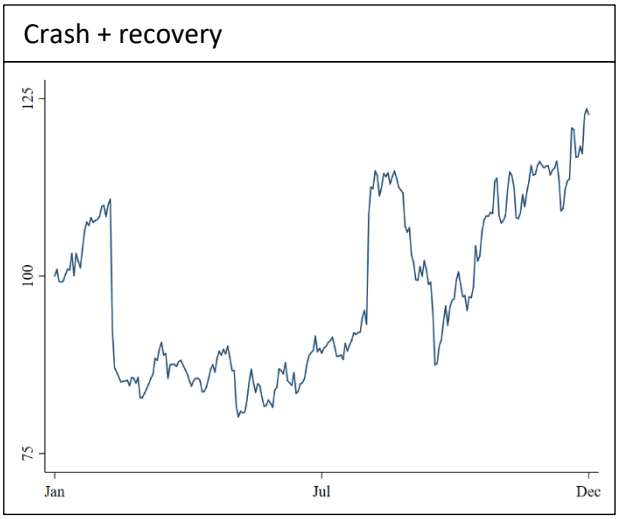
Figure 1: Visual representation of the price paths.

The price paths display the historical price movements of different individual stocks. The price charts are based on US stock data (2017) and taken from the Centre for Research in Security Prices (CRSP) by the Wharton Research Data Services.

Figure continues on next page.







Points of consideration methodology

Several problems arose during the testing phase of the experiment. The first was that participants believed that the short time window was an error, or unintended. Another problem that is relevant to the previous is that participants 'wanted a back button'. As time of exposure to the charts is fundamental to the experiment, this request could not be satisfied. To solve these problems in the best possible way, the introductory explanation was improved and elaborated, without giving away too many details on the treatments, to avoid the demand effect. The second problem was that participants sometimes were demotivated by the short time horizon. Especially subjects who had little financial knowledge were somewhat demotivated because the experiment was already difficult, making it even more difficult with such little time. However, the opposite was also true in that some subjects felt challenged by the short time window. These subjects knew that they had to pay more attention to make the right judgments. To motivate the former participants, more effort was put into assuring the participants that there were no right or wrong answers and that their response would always be of added value to the research. Additionally, before starting the actual questions (after the test questions) it was acknowledged that the survey was indeed not easy, to reinsure anxious participants. Lastly, the long treatment sometime lost some motivation too, as the experiment took considerably longer. This was not a huge issue, as they often finished the survey.

4. Results

Descriptive statistics

The mean scores for the dependent variables, for each of the individual charts, are presented in table 2 as in Borsboom and Zeisberger (2020). Substantial variation is observed between the mean scores within the treatment. The lowest mean score for perceived risk in the short treatment was 2.80 (chart 1). The

highest mean score for perceived risk was 4.97 (chart 11). Similarly, substantial differences exist in the mean scores for expected return and willingness to invest, for both treatments.

Borsboom and Zeisberger (2020) make use of charts that have identical return and standard deviation, this paper does not. Therefore, the considerable differences between the scores per chart are much more logical in this paper. However, they indicate that respondents indicated their preferences relatively strongly, and that mean return and standard deviation were likely to have an effect on the variety of mean scores for the dependent variables. As was evident from the existing literature, salient features such as lows/highs, recoveries, probability of loss and other characteristics have been shown to affect risk perception (Borsboom & Zeisberger, 2020; Grosshans & Zeisberger, 2018; Nolte & Schneider, 2018). Average return and standard deviation are controlled for in the regression analysis.

The differences between treatments are relatively small, yet very much existent. When considering chart 4, for example, the difference in perceived risk between the treatments is 0.84. Interestingly, the mean scores for expected return are relatively low for charts with high perceived risk. One would expect, according to standard finance theory, that more risky investments would go paired with higher expected return. However, this appears to not be the case in this dataset. This may be explained by investor sophistication; however, the expected relationship does also not hold true in Borsboom and Zeisberger (2020).

Table 2: Mean scores for perceived risk, expected return and willingness to invest for each chart, per treatment group.

Short treatment				Long treatment			
Chart	Risk	Expected return	Willingness to invest	Chart	Risk	Expected return	Willingness to invest
1	2.80	5.13	4.75	1	2.85	4.46	5.05
2	3.04	5.00	4.89	2	3.11	4.16	4.64
3	3.46	5.10	5.16	3	3.72	4.17	4.42
4	3.21	4.28	4.52	4	4.05	5.07	4.33
5	3.11	3.09	3.60	5	2.91	3.03	3.47
6	3.41	3.38	3.96	6	3.58	3.00	3.60
7	3.40	3.32	3.50	7	4.18	3.53	3.33
8	4.39	3.89	2.78	8	4.28	3.95	3.04
9	4.58	2.68	2.30	9	5.25	2.30	3.24
10	4.18	3.15	2.57	10	4.35	3.53	3.30
11	4.97	3.00	3.11	11	4.91	3.71	2.78
12	4.77	2.78	2.74	12	4.69	2.38	2.83
13	3.53	4.53	4.23	13	3.89	4.83	4.27
14	3.56	4.50	3.83	14	3.50	3.96	4.04
15	4.94	3.25	2.66	15	4.64	2.62	2.92

Table 2 presents the mean scores for the three dependent variables for each different chart. All three dependent variables were scored on a 7-point Likert scale. The scores are shown for both the short and the long treatment.

The descriptive statistics per treatment (n=157) are provided in table 3. Age is measured continuously. Three financial knowledge questions were asked, resulting in a financial literacy variable with min=0 and max=3. All other variables were scored on a 7-point Likert scale, as mentioned previously (appendix D and E). There are several interesting findings in the summary statistics.

Table 3: Descriptive statistics per treatment.

	Treatment 1: Short (81 Observations)		Treatment 2: Long (76 Observations)	
	Mean	Standard-deviation	Mean	Standard-deviation
Age	21.41	14.01	18.35	9.60
Knowledge	3.04	1.56	2.73	1.45
Risk taking	2.72	1.57	2.62	1.53
Understanding	3.51	1.68	3.75	1.82
Benefit_time	4.72	1.94	2.16	1.45
Financial literacy	1.93	1.00	1.76	1.16
	Treatment 1: Short (1215 Observations)		Treatment 2: Long (1119 Observations)	
Riskiness	3.86	1.61	4.02	1.71
Expected return	3.87	1.64	3.63	1.71
Willingness to invest	3.63	1.79	3.67	1.76
Time per question	5.32	4.12	7.14	11.06

First, the mean score for knowledge was higher in the short treatment, although the difference is only slight. Ironically, the short treatment scored lower on understanding, while they indicated to be more knowledgeable. This may imply that the experiment was more difficult for the short treatment. Indeed, it was evident that the experiment was experienced as quite difficult. This can be seen within the relatively low mean scores for understanding in both treatments. Risk taking is similar in both treatments and again on the low side, indicating risk aversion. The biggest difference is how the treatment groups felt they would have benefitted from extra time. Logically, the short treatment indicated they would have benefitted extremely from extra time. This is not a bad thing, because remember; the time window was purposely chosen to be extremely short to ensure that participants were relying on their visual attention rather than cognitive attention to answer the questions. Lastly, financial literacy was about equal in both treatments, being slightly higher in the short treatment. This is in line with the fact that knowledge too was higher in the short treatment.

Secondly, the dependent variables of interest. The short treatment comprises of 76 x 15 = 1119 total observations, bar some missing values. The long treatment comprises exactly 81 x 15 = 1215 total observations. These values amount to the total amount of answers and are divided about equally across the three dependent variables. The dependent variables will be analyzed more formally in the next section; however, we can already find some interesting facts from the descriptive statistic. The mean answers are relatively close for the two treatments. The mean score for riskiness is higher in the long treatment. The mean score for expected return is higher in the short treatment despite the expectation that the treatment perceiving higher risk would also expect higher return, according to basic risk-return trade-off. The mean score for willingness to invest is about identical between treatments.

Interestingly, the mean time participants took to answer the question, was higher in the long treatment. One would expect that the short treatment needed longer to process what they had seen to answer the question, whereas the long treatment had enough time to form a decision and almost immediately answer the question. Instead, it appears participants in the short treatment also provided

answers in a shorter time span, and participants in the long treatment provided answers in a longer time span. This could also indicate that some participants in the short treatment may have given up after some time, simply answering to finish the survey more quickly. However, this statistic may be somewhat difficult to interpret, for some participants left open the decision for a couple minutes before answering, thereby heavily influencing the time taken per question.

Finally, it is interesting to mention that several participants in the long treatment did not finish the entire experiment. Instead, they stopped mid-way through more often than the participants in the short treatment. However, this was not a problem, as participants who completed <80% of the experiment were excluded.

Sample t-test

Table 4 below summarizes the results of the parametric sample t-tests. The results denote the between-subject test of the null hypothesis that states there is no significant difference between the mean scores in the two treatment groups for the variable of interest, like in Diacon and Hasseldine (2007).

Table 4: Sample t-test: mean comparison between treatments.

	Difference = mean (long) - mean (short)	Ha: diff<0	Ha: diff!=0	Ha: diff>0
Entire sample				
Riskiness	.161	.913	.174	.0870*
Expected return	-.244	.0213**	.0425**	.979
Willingness to invest	.0437	.634	.732	.366
Time per question	1.822	1.000	0.000***	0.000***
Benefit_time	-2.557	0.000***	0.000***	1.000

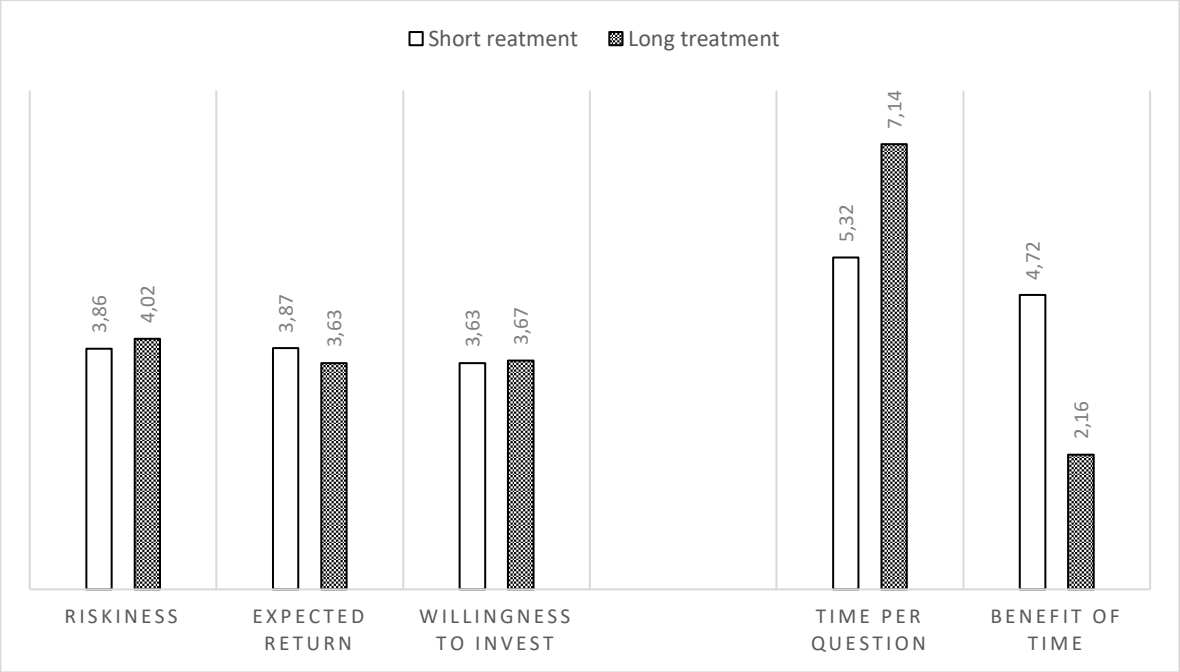
P-values in parentheses.
Significance is indicated with * or ** or *** at the 10%, 5% and 1% level, respectively.

As was previously evident from the summary statistics, the mean riskiness score was higher in the long treatment, indicating that overall, participants in the long treatment perceived the investments to be riskier. The difference is statistically significant at the 10% level. Expected return is statistically significant at the 5% level. However, contrary to riskiness, the mean score is now higher in the short treatment. Thus, visual attention has a significant positive effect on risk perception, and visual attention has a significant negative effect on expected return. The effect on perceived risk is consistent with the hypothesis, whereas the effect on expected return is opposite to the hypothesized. Apparently, when the decisions were judged riskier, participants did not require increased return. Willingness to invest is the only variable that is not significantly different between the two treatments. Therefore, the time of attention has no influence on willingness to invest. the results are visualized using a bar chart in Figure 2.

Additionally, the t-test was used to examine the difference between the time taken per question and the benefit participants believed they would have had from having more time. Both are statistically significant at the 1% level. Contrary to the expected, the long treatment – which had longer to analyze the graph – also took longer to actually make the decision. In line with expectations, on the other hand, the short treatment indicated that they would have benefitted from having more time, much more than the long treatment.

Figure 2: Bar chart sample t-test on dependent variables.

The bar chart graphically presents the mean differences between the treatments. Riskiness is significant at the 10% level. Expected return is significant at the 5% level. Willingness to invest is insignificant. The time taken per question and the benefit of having more time are both significant at the 1% level.



Regression results

The regression is provided as a means for robustness. Table 5.1 provides the regression results for the regression in which the treatment and mean daily return are interacted. Table 5.2 provides the regression results in which the treatment and the daily standard deviation are interacted. Both tables are merged in appendix F, which may increase comprehensiveness for some readers. Importantly, there is no heteroskedasticity problem due to the Likert scale. With a Likert scale, there are no outliers. This was confirmed by the Breasch-Pagan test for heteroskedasticity.

The regression makes use of a treatment dummy to determine the effect of visual attention on the dependent variables. The short treatment is zero, the long treatment is one. This means that the coefficient for the treatment variable can be interpreted as moving from the short treatment to the long

treatment. In other words, the coefficient of the treatment variable is the effect of increasing visual attention.

According to the hypotheses, the coefficient of the treatment variable is expected to be positive for perceived risk and expected return, and negative for willingness to invest. The t-test showed that the effect on riskiness was positive. However, contrary to the hypothesised, the effect on expected return was negative. The effect on willingness to invest was insignificant.

*Table 5.1: Regression with interaction Treatment*Mean return.*

	Risk perception	Expected return	Willingness to invest
	Coefficient	*Coefficient*	*Coefficient*
Treatment	0.233	-0.079	-0.063
	(0.169)	(0.177)	(0.181)
Mean return	-113.847	297.553	16.679
	(185.329)	(182.054)	(198.549)
Standard deviation	47.697**	-35.572*	-64.127***
	(21.389)	(18.825)	(22.635)
Interaction	-30.546	33.422	25.142
	(31.495)	(31.613)	(31.457)
Age	0.009	-0.006	-0.003
	(0.006)	(0.006)	(0.005)
Knowledge	-0.080	-0.034	-0.007
	(0.060)	(0.056)	(0.061)
Risk taking	0.055	0.026	0.099**
	(0.046)	(0.044)	(0.050)
Benefit of time	0.064*	0.038	-0.023
	(0.039)	(0.041)	(0.044)
Financial literacy	-0.005	-0.155**	-0.011
	(0.072)	(0.070)	(0.079)
Constant	2.549***	5.212***	5.498***
	(0.588)	(0.534)	(0.617)
Observations	597	583	590
R-Squared	0.201	0.294	0.228
Controls	Yes	Yes	Yes

Standard Errors in parentheses.
Significance indicated with * or ** or *** at the 10%, 5% and 1% level, respectively.

Controls not separately included: Time taken per question, gender, understanding of the survey, path type (categorical),

The effect of the treatment variable is statistically insignificant for all three dependent variables. The sign of increasing visual attention is positive on risk perception, and negative on expected return and willingness to invest. This is in line with the results of the sample t-test. However, as the effect is statistically insignificant, it weakens the robustness of the result.

The fact that the regression does not show a significant effect can have various explanations. Most likely, it is due to the small systematic difference that was observed in the sample t-tests. The difference might be too small to be seen in the regression. This may be confirmed by the fact that the treatment variable is only barely not significant. This in turn is likely to be caused by several fundamentals of the experiment. The two main problems are the sample and the time windows, as discussed further in the discussion section.

In accordance with standard finance theory, standard deviation has a significant effect on risk. The direction is positive. Standard deviation is a general measure for higher investment risk, as it indicates higher volatility. The effect on willingness to invest and expected return is negative, which would be expected as risk increases.

The interaction term is insignificant. It would have been interesting to see the effect of mean return be influenced by visual attention. No such significant effect was found. Although a significant effect of visual attention on mean return would have strengthened the result and added to the robustness of the results, the lack thereof does not discredit the relevance of visual attention completely.

*Table 5.2: Regression with interaction Treatment*Standard deviation.*

	Risk perception	Expected return	Willingness to invest
	Coefficient	*Coefficient*	*Coefficient*
Treatment	0.516**	0.048	-0.350
	(0.261)	(0.259)	(0.280)
Mean return	-164.704	343.892*	58.896
	(178.574)	(176.517)	(192.039)
Standard deviation	24.260	-48.600**	-41.089
	(28.497)	(24.638)	(29.857)
Interaction	14.582	9.083	-14.277
	(11.690)	(11.041)	(12.124)
Age	0.009	-0.007	-0.003
	(0.006)	(0.006)	(0.005)
Knowledge	-0.077	-0.029	-0.006
	(0.060)	(0.056)	(0.060)
Risk taking	0.054	0.020	0.102**
	(0.046)	(0.043)	(0.050)
Benefit of time	0.063	0.040	-0.025
	(0.039)	(0.041)	(0.044)
Financial literacy	-0.006	-0.155**	-0.012
	(0.072)	(0.070)	(0.079)
Constant	2.449***	5.129***	5.613***
	(0.593)	(0.546)	(0.621)
Observations	597	583	590
R-Squared	0.202	0.294	0.229
Controls	Yes	Yes	Yes

Standard Errors in parentheses.
Significance indicated with * or ** or *** at the 10%, 5% and 1% level, respectively.

Controls not separately included: Time per question, gender, understanding, path type (categorical).

In the second regression, where the treatment variable and standard deviation are interacted, the treatment variable is in fact significant. However, it is only significant for risk perception. The direction of the effect is positive, indicating that increased visual attention results in higher perceived risk. This result is in line with what was found using the t-test (Table 4). The interaction term is again insignificant.

Mean return has a significant effect on expected return. Logically, the coefficient is positive, implying that increased mean return is associated with higher expected return. It is significant at the 10% level and standard deviation is significant at the 5% level. The coefficient is negative, meaning that a higher standard deviation has a significant negative effect on expected return. This is surprising, as standard deviation is a measure for risk. When risk is increases, so should the expected return. Moreover,

the effect is only significant for expected return, not for riskiness and willingness to invest. If the effect were found to be significant, it would be expected that standard deviation had an effect on perceived risk. However, some literature suggests that the link between variance (measured by standard deviation) and return is weak (Baillie & DeGennaro, 1990). Investors consider some other factors to determine the riskiness of investments, which is consistent with the analysed literature.

5. Conclusion

In this study, the channel through which framing may affect investment decisions was considered in greater detail. In an experimental setting, the effect of visual attention on perceived risk, expected return and willingness to invest was examined. To our knowledge, no such literature previously existed. Therefore, this study forms the benchmark in determining the time windows to measure the variable visual attention. An analysis of the existing framing literature combined with cognitive focussed literature formed the framework for the analysis. Framing is an ever-relative topic in behavioural economics, due to the heavy psychological influence. Since financial service providers can selectively display information in a way that is beneficial to them, the enquiry is also ethically relevant.

To test the hypotheses, an experiment was created in which participants were divided between two treatments that were given different time windows to make investment decisions. The short treatment had two seconds to analyse the price charts, whereas the long treatment had ten seconds to analyse the charts. The time window was the only variable that was manipulated. Participants had to answer one randomly selected investment question (they were equally represented) for fifteen different charts, amounting to fifteen observations divided across the three dependant variables per participant. The charts were displayed in random order, and several chart categories were used. These categories were up-down, neutral, up-down and displaying a crash. To analyse the results, a sample t-test was used, as there were enough observations to assume the data being normally distributed, allowing for the usual parametric tests.

When investors are confronted with little visual attention, they are expected to dramatically oversimplify and perceive less risk. Visual attention was found to significantly influence investment decisions. Two out of the three dependant variables were statistically significant. That is, visual attention was found to have a positive effect on perceived risk, and visual attention was found to have a negative effect on expected return. There was no such effect found of visual attention on willingness to invest.

In summary, visual attention has a significant effect on investment decisions. However, to get a better understanding, more research should be conducted. More time windows should be tested and different samples should be tested to gain more definitive results. Practical implications include the importance of time of exposure for investors and the relevance for financial service providers. As

financial service providers can selectively display information, they should be monitored when providing the frames for financial services, including time of exposure.

6. Discussion

The difference in the mean scores of the investment decisions may also be explained by loss aversion and/or regret aversion. That is, investors in the long treatment were able to better analyse the charts, potentially giving them a worse feeling had they made an undesirable decision. The short treatment would likely feel considerably less regret, would they have made an undesirable decision.

The effect on perceived riskiness may also have been influenced by the convexity and concavity of the price charts. Convexity and concavity of the price charts may have impacted the participants in one of the treatments more. More carefully constructed price paths regarding convexity and concavity may influence perceived risk less dramatically.

Willingness to invest, was the only dependent variable that was not found to be significant using the t-test. This might be, at least in part, explained by the conservative answers by the participants. The sample did not consist of experienced investors, and a large share of the sample was teenagers, likely having no investment experience at all. Willingness to invest is naturally lower for people who have never invested as compared to people who have previous experience with investing. Such participants express their willingness to invest less extremely, resulting in mean scores that lay relatively close together.

There are two main points of discussion that are obvious in this paper: the sample and the time windows. Preferably, one would have executed the experiment with a sample of sophisticated investors. However, resources were limited due to lack of funding and reach. The observed effects might be stronger in a sample of sophisticated investors. Additionally, unsophisticated participants appeared to be more likely to be demotivated. Demotivated participants are likely to rush through the questions and give less thought to their answers. This is undesirable, yet unpreventable in a study without financial incentivization. In general, the difficult nature of this experiment was relatively unsuited for a sample of unsophisticated investors.

The second difficulty was choosing correct time windows. This is one of the first studies assessing the relationship between visual attention and investment decisions. Although exciting, it also comes with several difficulties. This paper provides a benchmark and determining a benchmark is not an easy task. Due to the format this study was conducted in, a master's thesis, there was no possibility to assess the perfect amount of time for the time windows. Including multiple time windows could have

improved the robustness of the results. Therefore, future studies should test more time windows and, of equal importance, assemble a sample consisting solely of sophisticated investors.

This study provides relevant insight regarding the channel through which framing influences decisions, rather than examining yet another type of frame. As this is the first study to assess that relationship, it is a relevant addition to existing literature on framing. Importantly, the presented findings have some interesting practical implications. According to Smeets and Riedl (2013), fund managers may benefit from different marketing strategies regarding different funds. The results presented here suggests that taking into account visual attention in marketing strategies could be beneficial. That is, shorter visual attention may have positive implications. However, a different side to the same coin exists. Fund managers may cherry pick the information that is displayed in advertisements – and also influence the channel through which it is presented – which is often considered to be unethical, as explained by Diacon and Hasseldine (2007).

In summary, a more elaborate study with sophisticated investors, as well as multiple time windows, would be a great extension to this paper and could be of great value to existing framing literature.

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8. Appendix

Appendix A: Introductory text.

Language can be changed to Dutch/English in the top right corner.

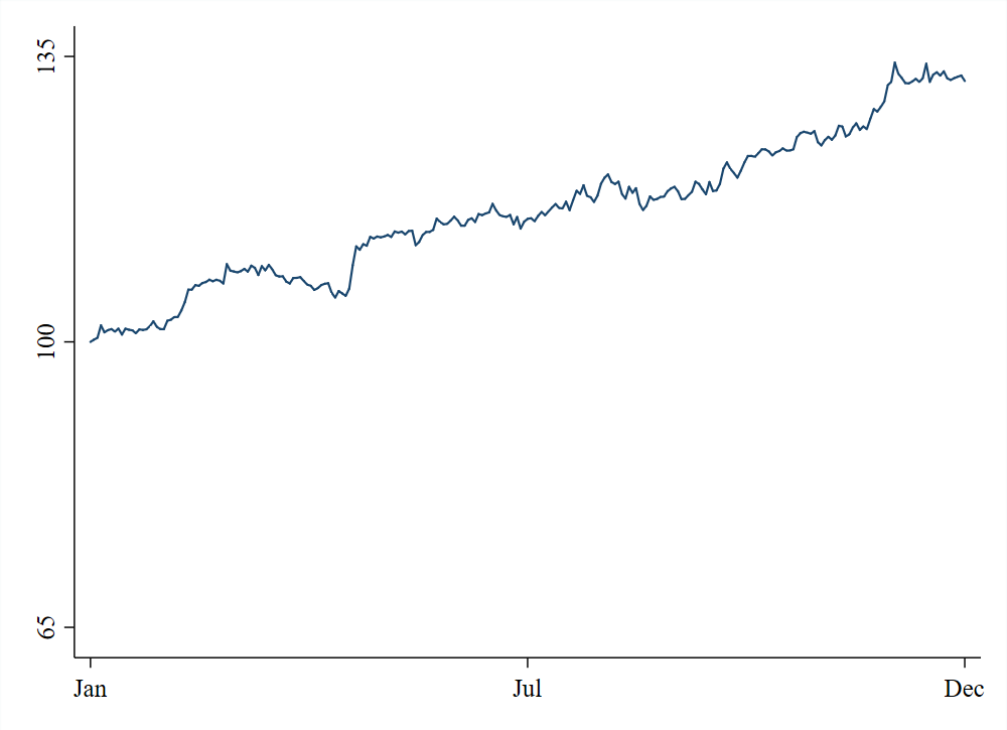
Dear Participant,

In this survey, you will be asked to make simple investment decisions. Each decision is based on the **historical** price development of an individual stock. Every decision has limited time; therefore, it is **not** needed to make an in-depth analysis. Rather, you give more of an indication based on how you perceive the investment. Each question consists of two parts. First, you will see a price chart. Second, you will answer a question on the next screen. There are no right or wrong answers. Even if you find the questions to be difficult, you help me tremendously by finishing the survey! The questionnaire will start with 3 test questions. After that, the 15 actual questions start.

Complete anonymity is ensured in this survey. Thank you for filling out the survey. It should take around 5 to 10 minutes.

We will now start with 3 test questions to give you a feel for the survey. The variables on the X and Y axis do not change, so you do not have to look at that every time. Please notice that the question you have to answer is different for every chart. These are the three different questions you will have to answer for the actual charts as well. All the charts will be displayed for the same amount of time. This includes the following test questions.

Appendix B: Example of a price path and the corresponding question. Only one of the three questions are displayed per price path.



Please indicate how risky you perceived this investment to be, on a scale from 1 to 7.

	Low (1)	2	3	4	5	6	High (7)
Riskiness	○	○	○	○	○	○	○

Please indicate what you expect the return to be, on a scale from 1 to 7.

	Low (1)	2	3	4	5	6	High (7)
Expected return	○	○	○	○	○	○	○

Please indicate how willing you are to invest, on a scale from 1 to 7.

	Low (1)	2	3	4	5	6	High (7)
Willingness	○	○	○	○	○	○	○

Appendix C: An overview off all the price paths.

All participants saw the same price paths, but in random order. The charts are categorized into four categories. They are down – up (top row), Steady (second row), up – down (third row), crashes (bottom row).

Appendix D: Financial literacy questions.

Please answer the following three questions. These questions give an indication of your financial knowledge so please answer on your own.

Suppose you put €1000 in a savings account and the interest rate is 4% annually. After three years, how much money do you have in your savings account?

- ○ Less than €1120
- ○ Exactly €1120
- ○ More than €1120

Suppose the interest rate is 4% annually and inflation is 5% annually. After one year, how much would you be able to buy with the money in your savings account?

- ○ Less than today
- ○ The same as today
- ○ More than today

Please indicate whether the following statement is true or false: 'Holding a single company's stock is usually less risky than investing in a mutual fund.'

- ○ True
- ○ False

Appendix E: General characteristics questions.

What is your gender?

- ○ Male
- ○ Female
- ○ Prefer not to answer

What is your age? (leave empty if prefer not to answer)

_____

How good do you think your knowledge of investing is?

	Low (1)	2	3	4	5	6	High (7)
Knowledge	○	○	○	○	○	○	○

In general, how much (financial) risk do you take?

	Low (1)	2	3	4	5	6	High (7)
Risk taking	○	○	○	○	○	○	○

How well did you understand the provided information and the posed questions in this survey?

	Low (1)	2	3	4	5	6	High (7)
Understanding	○	○	○	○	○	○	○

Would you have benefitted from having more time to see the charts?

	Low (1)	2	3	4	5	6	High (7)
Benefit	○	○	○	○	○	○	○

Appendix F: Regression results, merged into one comprehensive table.

	Risk perception	Expected return	Willingness to invest	Risk perception	Expected return	Willingness to invest
	Coefficient	*Coefficient*	*Coefficient*	*Coefficient*	*Coefficient*	*Coefficient*
Treatment	0.233	-0.079	-0.063	0.516**	0.048	-0.350
	(0.169)	(0.177)	(0.181)	(0.261)	(0.259)	(0.280)
Mean return	-113.847	297.553	16.679	-164.704	343.892*	58.896
	(185.329)	(182.054)	(198.549)	(178.574)	(176.517)	(192.039)
Standard deviation	47.697**	-35.572*	-64.127***	24.260	-48.600**	-41.089
	(21.389)	(18.825)	(22.635)	(28.497)	(24.638)	(29.857)
Interaction	-30.546	33.422	25.142	14.582	9.083	-14.277
	(31.495)	(31.613)	(31.457)	(11.690)	(11.041)	(12.124)
Age	0.009	-0.006	-0.003	0.009	-0.007	-0.003
	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)	(0.005)
Knowledge	-0.080	-0.034	-0.007	-0.077	-0.029	-0.006
	(0.060)	(0.056)	(0.061)	(0.060)	(0.056)	(0.060)
Risk taking	0.055	0.026	0.099**	0.054	0.020	0.102**
	(0.046)	(0.044)	(0.050)	(0.046)	(0.043)	(0.050)
Benefit of time	0.064*	0.038	-0.023	0.063	0.040	-0.025
	(0.039)	(0.041)	(0.044)	(0.039)	(0.041)	(0.044)
Financial literacy	-0.005	-0.155**	-0.011	-0.006	-0.155**	-0.012
	(0.072)	(0.070)	(0.079)	(0.072)	(0.070)	(0.079)
Constant	2.549***	5.212***	5.498***	2.449***	5.129***	5.613***
	(0.588)	(0.534)	(0.617)	(0.593)	(0.546)	(0.621)
Observations	597	583	590	597	583	590
R-Squared	0.201	0.294	0.228	0.202	0.294	0.229
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Standard Errors in parentheses.
Significance indicated with * or ** or *** at the 10%, 5% and 1% level, respectively.

Controls not separately included: Time taken per question, gender, understanding of the survey, path type (categorical),

Appendix G: Correlation matrix.

Variables	1	2	3	4	5	6	7
1. Riskiness	1.000						
2. Mean return	-0.167	1.000					
3. Standard deviation	0.337	-0.108	1.000				
4. Age	0.039	0.007	0.000	1.000			
5. Knowledge	-0.070	-0.018	-0.009	0.12	1.000		
6. Risk taking	0.031	-0.028	0.018	0.050	0.40	1.000	
7. Treatment	-0.023	-0.001	-0.002	0.153	0.097	-0.028	1.000

The table shows the correlation between riskiness and some of the control variables. Not all dependent variables are included since it is not possible to compute the correlations due to a lack of observations.