


































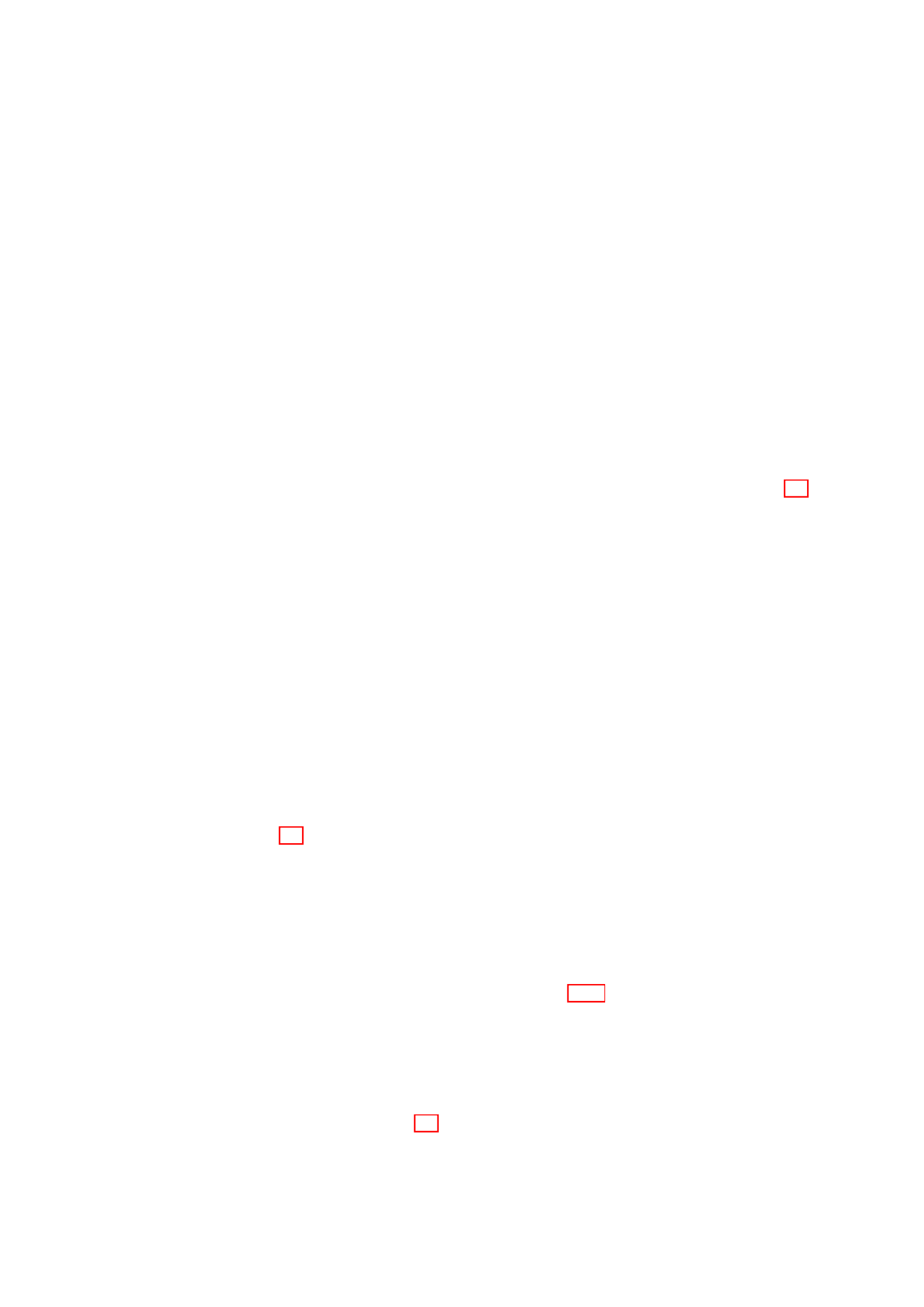

Table 4.4: Belief Distortion and Category Changes

This table contains the coefficients and t-statistics (in parentheses) of OLS regressions in which the dependent variable is subject's belief distortion estimated each period by subtracting the objectively correct Bayesian probability from subject's indicated probability that the stock pays a positive outcome in percent (from 1 to 100), *Belief Distortion*. *Category Treatment* is a dummy variable equal to one for observations from the *Category* condition and zero for observations from the *Disaggregated* condition. *Subject* is a dummy variable controlling for subject fixed effects. The models report results for observations with stock outcomes that suggest a category change (column 1) and for observations with stock outcomes that do not suggest a category change (column 2). *, **, and *** denote significance at the 10%, the 5%, and the 1% level, respectively.

	(1) Belief Distortion (Cat. Change)	(2) Belief Distortion (No Cat. Change)
Category Treatment	3.322***	0.063
	(2.67)	(0.08)
Constant	-2.600	-1.291
	(-0.59)	(-0.25)
Subject	Yes	Yes
N	580	968
R^2	0.33	0.35

the good, mediocre, or bad industry.

The results indicate that if the suggested category C* is the good industry, subjects form distorted beliefs after a category change. Subjects' then form overly optimistic beliefs about the stock paying a positive outcome in the future. By contrast, in case of no category change, subjects do not deviate significantly from the Bayesian probability. This result is again in line with our hypothesis 3 (overreaction), but not supportive of our hypothesis 2 (underreaction). That is, subjects tend to overreact to a change to the good industry with too optimistic beliefs that are 3.7% higher than the Bayesian probability (T-test, $p < 0.05$). Yet, they do form correct beliefs without a category change. However, the opposite pattern is observed for subjects' belief if the suggested category C* is the bad industry. Subjects' form their beliefs correctly in case of a change to the bad industry, but overreact to information consistently suggesting that C* is the bad industry. That is, in case of no category change subjects form overly pessimistic beliefs about the stock paying a positive outcome, on average 2.6% lower than the Bayesian probability (T-test, $p < 0.01$). If the suggested category C* is the mediocre industry, subjects form correct beliefs in both cases with and without category change.

Our findings indicate that subjects' overreaction to new information after a category change is associated with the type of category. This could be related to the type of new information subjects observe. Note that in case of C* being the good industry, the new information is always a positive outcome and in case of C* being the bad industry, the new information is always a negative outcome.

case of no category change the increase is 4.6% ($p < 0.1$). The coefficients of the two models are significantly different (Wald test, $p < 0.01$). Thus, subjects invest significantly more in the risky stock in the *Category* condition than in the *Disaggregated* condition after a category change compared to the case of no category change.

Table 4.6: Category-Based Investment Decisions

This table contains the coefficients and t-statistics (in parentheses) of Probit regressions in which the dependent variable is a dummy variable which is equal to one if the subject invested in the stock. *Category Treatment* is a dummy variable equal to one for observations from the *Category* condition and zero for observations from the *Disaggregated* condition. *Subject* is a dummy variable controlling for subject fixed effects. The models report results for all observations (column 1), for observations with stock outcomes that suggest a category change (column 2) and for observations with stock outcomes that do not suggest a category change (column 3). *, **, and *** denote significance at the 10%, the 5%, and the 1% level, respectively.

	(1) Stock Invest	(2) Stock Invest (Cat. Change)	(3) Stock Invest (No Cat. Change)
Category Treatment	0.329***	1.079***	0.262**
	(3.78)	(4.98)	(2.12)
Constant	1.204**	4.883	0.673
	(2.34)	(0.04)	(1.06)
Subject	Yes	Yes	Yes
N	1,056	317	577
Pseudo R^2	0.18	0.25	0.18

Category changes, i.e. observed outcome series with the latest information changing the suggested industry belonging, lead to an increase of stock investings. This investment behavior is in line with our finding of more optimistic beliefs in the *Category* condition after a category change (Table 4.4) and Mullainathan's (2002) idea that people over-respond to a series of outcomes suggesting a category change. Table 4.7 provides further evidence for biased beliefs driving this investment behavior. The table displays the results of Probit regressions models with the investment dummy variable as dependent variable. Subjects' beliefs, i.e., indicated probability estimates during the experiment, serve as independent variable. We control for the objectively correct Bayesian probability and subject fixed effects. The regression models report results for all observations (column 1) and seperately for cases of a suggested category change (column 2) and no suggested category change (column 3) by the observed outcomes. The regression results show that subjects' decision to invest in the stock is positively correlated with their subjective beliefs ($p < 0.01$). This effect is stronger after a category change, but is insignificant for cases with no category change.

A key question is whether this observed investment behavior is associated with actual mistakes. Table 4.8 shows that this is not the case. The table reports results from Probit re-

Table 4.7: Subjective Beliefs and Investment Decisions

This table contains the coefficients and t-statistics (in parentheses) of Probit regressions in which the dependent variable is a dummy variable which is equal to one if the subject invested in the stock. *Bayesian Posterior* is the value of the objective Bayesian probability that the stock pays a positive outcome in percent (from 1 to 100). *Subjective Belief* is the subject's indicated posterior belief that the stock is the good stock in percent (from 1 to 100). *Subject* is a dummy variable controlling for subject fixed effects. The models report results for all observations (column 1), for observations with stock outcomes that suggest a category change (column 2) and for observations with stock outcomes that do not suggest a category change (column 3). *, **, and *** denote significance at the 10%, the 5%, and the 1% level, respectively.

	(1) Stock Invest	(2) Stock Invest (Cat. Change)	(3) Stock Invest (No Cat. Change)
Bayesian Posterior	0.022	-0.003	0.052*
	(0.90)	(-0.04)	(1.65)
Subjective Belief	0.020***	0.063***	0.008
	(2.76)	(2.61)	(0.89)
Constant	-1.114	2.311	-2.435
	(-0.90)	(0.00)	(-1.62)
Subject	Yes	Yes	Yes
N	336	43	216
Pseudo R^2	0.22	0.29	0.19

gressions for subjects' suboptimal investment decisions from a Bayesian perspective, assuming risk neutrality. We use two suboptimal choice variables as dependent variables. First, we use a dummy variable for a suboptimal choice to invest in the stock, which is equal to one if the subject chose to invest in the stock, although the stock's expected outcome was lower than the bond's outcome (column 1 and 2). Second, we include regression models with a dummy variable for a suboptimal choice to invest in the bond as a dependent variable. The dummy variable is equal to one if the subject invested in the bond, although the bond's outcome was lower than the stock's expected outcome (column 3 and 4). Results are reportet separately for all observations (column 1 and 3) and observations after a category change (column 2 and 4). As independent variable we use the category treatment dummy variable. Note that we implemented our treatments within-subjects. Although individual risk preferences can explain deviations from this Bayesian benchmark, they cannot explain differences between our treatments. We control for subject fixed effects. The results show that subjects make significantly fewer investment mistakes in the *Category* condition compared to the *Disaggregated* condition, both regarding stock investments (column 1) as well as bond investments (column 3). After a category change this effect is even stronger in case of bond investments (column 4), but diminishes in case of stock investments (column 3). Thus, subjects seem to be more likely to avoid suboptimal investment decisions in the *Category* condition compared to the *Disaggre-*

gated condition, especially they are more likely to avoid suboptimal investments in the bond after a category change.

This findings is based on a comparison to a Bayesian benchmark assuming that subjects behave in a risk neutral manner. As these results imply an increase in risk taking, the finding might change for subjects with strong risk aversion. However, this would only affect the classification of the decision as a mistake, not the treatment effect per se. Note that we compare behavior within-subjects and changes in risk taking across treatments are more likely to be driven by the decision problem compared to personal preferences.

Table 4.8: Suboptimal Investment Decisions

This table contains the coefficients and t-statistics (in parentheses) of Probit regressions in which the dependent variable is a dummy variable which is equal to one if the subject invested in the stock with a lower expected outcome than the bond, *Suboptimal Stock Invest* or a dummy variable which is equal to one if the subject invested in the bond with a lower expected outcome than the stock, *Suboptimal Bond Invest*. *Category Treatment* is a dummy variable equal to one for observations from the *Category* condition and zero for observations from the *Disaggregated* condition. *Subject* is a dummy variable controlling for subject fixed effects. The models report results for all observations (column 1 and 3) and for observations with stock outcomes that suggest a category change (column 2 and 4). *, **, and *** denote significance at the 10%, the 5%, and the 1% level, respectively.

	(1) Sub. Stock Invest	(2) Sub. Stock Invest (Cat. Ch.)	(3) Sub. Bond Invest	(4) Sub. Bond Invest (Cat. Ch.)
Category Treatment	-0.173*	0.262	-0.185*	-0.792***
	(-1.73)	(0.99)	(-1.92)	(-3.72)
Constant	-4.917	-5.350	-1.279**	-5.123
	(-0.05)	(-0.02)	(-2.47)	(-0.02)
Subject	Yes	Yes	Yes	Yes
N	936	203	876	292
Pseudo R^2	0.16	0.08	0.16	0.20

5 Conclusion

This study uses an experimental approach to examine the role of coarse categories in individuals' learning from financial information and subsequent investment decisions. In particular, we (i) test the theoretical predictions by Mullainathan (2002) in an investment context, (ii) explore differences in category-based belief formation and (iii) link category-based beliefs to investment behavior.

We document that subjects form category-based beliefs as predicted by Mullainathan (2002) when the observed stock belongs to "good" stock categories associated with gains. People then overreact to category changes, form overly optimistic beliefs, and invest signif-

icantly more in the stock compared to a situation with no category change, but the same quality of the stock. Yet, we find the opposite result if the stock belongs to bad stock categories associated with losses. People then seem to be sensitive to the stock's outcome and even overreact to negative information with too pessimistic beliefs if there is no category change. Moreover, we observe a stronger category effect in case of asymmetric category sizes. If the "good" stock category is larger relative to other categories, the category-based belief distortion is higher. We further show that subjects' overreaction to category changes is associated with higher stock investments. Interestingly, this tendency correlates with fewer suboptimal investment decisions in our experimental setting.

The study's results enhance the understanding of how people learn from financial information when aggregated category information, such as industry information, is present. This kind of information aggregation along stock categories is very common in financial market media. Further, our study provides experimental evidence of category-based belief distortion in investment decision-making and thereby (i) complements theoretical work on how categorical thinking affects economic choice (Mullainathan, 2002; Mullainathan et al., 2008) and (ii) shows that categorical thinking by itself is a cognitive limitation that influences investor learning beside pure attentional constraints.

The findings documented in this paper open interesting avenues for further research. First, future work could investigate whether our observed effect on investment decisions is robust to making the experimental environment closer to the typical investment environment. For example, it would be interesting to look at whether the results hold for modifying the risky asset's return distribution or the delay between investment choice and return realization as done in the field experimental study by Beshears et al. (2017) with respect to return information aggregation effects. Further, we show differences in subjects' belief formation based on category types. Future research could explore how different market states, i.e., up or down markets, influence category learning. This might uncover important insights into how individuals form expectations and decide to participate in the stock market during different states in financial markets.

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A Appendix

A.1 Experimental Instructions

(translated from German)

Introduction

Welcome to our financial decision making study

For the duration of the study, we ask you to follow a few rules. Should there be questions, please raise your hand and an experimenter will answer your question privately. We ask you not to communicate with each other or use a calculator during the study.

We also ask you to turn off your cell phones and other devices, or at least to put them on silent, and to pack them away with your bag or belongings. We do not want you or other participants to be disturbed or distracted. If you do not adhere to these rules, this will lead to an automatic exclusion from the study and from payment.

The study will last approximately 1.5 hours.

After the study, you will receive a payout for your participation. The actual amount will depend on your decisions in the experiment and luck.

Everyone will earn 15 EUR for participating in this study. In addition, the computer will randomly pick three out of the present participants who get paid his or her earnings from one of the study's tasks.

Please press 'proceed' to continue with the general instructions.

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General Instructions

In this study you complete investment tasks, related to two securities: a risky security (i.e., a stock with risky payoffs) and a riskless security (i.e., a bond with a known payoff), and will

provide estimates as to how good an investment in the risky security is.

Please click 'proceed' to continue with the detailed instructions for the tasks. Take your time to read the instructions carefully. Note that you cannot go back to previous pages. Please let us know if you have any questions.

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Detailed Instructions

Stages of the Study

The experiment consists of **five stages**.
In each stage, you will decide to invest in one of two securities: a risky security (i.e., a stock with risky payoffs) and a riskless security (i.e., a bond with a known payoff).

Either way, you start with an endowment of 35 EUR. In addition to this endowment, you will get payoffs from investing.

Each stage consists of 7 investment periods. For each period you can decide wether to invest in the stock or bond, thus you will make 7 decisions. After each period you will earn a payoff from your investment.

Before each block you will be provided with extra information about the stock and the bond. This information can influence your willingness to invest in the stock or bond. **Thus, please read this information carefully – the information is different for each stage.**

If you choose to invest in the bond, you get a payoff of 6 EUR for sure in each period.

If you choose to invest in the stock, you will receive a dividend in every period, which can be either positive or negative. A positive dividend is 20 EUR and a negative dividend is -5 EUR.

At the end of each stage you will have earned your accumulated payoffs from the investment plus your initial endowment of 35 EUR.

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Stock evaluation task

You will then see the dividends of the stock, no matter if you chose to invest in the stock or the bond.

After that, we will ask you to tell us two things:

(1) what you think is the probability that the stock pays a positive outcome (the answer must be a number between 0 and 100);

(2) how much you trust your ability to come up with the correct probability estimate that the stock pays a positive outcome. In other words, we want to know how confident you are that the probability you estimated is correct.

There is always an objective, correct, probability that the stock pays a positive outcome, which depends on the history of dividends paid by the stock already.

If you provide us with a probability estimate that is within 5% of the correct value (e.g., correct probability is 80% and you say 84%, or 75%) you will earn 20 EUR for each correct estimate. In total you can earn up to 120 EUR in this task.

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Your final payment at the end of the study

Your final payment will be:

You will get paid 15 EUR for participating in our study regardless of your task earnings.

In addition, your earnings in one of the experimental tasks can determine your payment. We will randomly draw one of 10 participants out of each session (with maximum 30 participants) who will get paid one of her or his task earnings. The computer will randomly decide which

of the above-described tasks will determine the participants' payment. Remember, your task earnings depend on your decisions and answers:

Investment decision in each stage: Your initial endowment of 35 EUR and in each period either 6 EUR from investing in the bond or either 20 EUR or -5 EUR from investing in the stock.

Stock evaluation task in each stage: 20 EUR for each probability estimate that is within 5% of the correct value.

Information Provision

[*Category* condition]

You will soon have the probability to decide to invest either in the stock or bond.

If you decide to invest in a stock you earn the dividend paid by the stock, which can be positive or negative. The positive dividend is 20 EUR and the negative dividend is -5 EUR. The stock belongs to an industry, that determines how likely it is that the stock pays a positive dividend. The stock can belong either to the good, mediocre, or bad industry. A stock from the good industry pays a positive dividend of 20 EUR with a probability of 70% and a negative dividend of -5 EUR with a probability of 30%. A stock from the mediocre industry pays a positive and negative dividend with equal probability, i.e., 50%. If the stock belongs to the bad industry, the stock pays a positive dividend of 20 EUR with a probability of 30% and a negative dividend of -5 EUR with a probability of 70%.

Initially, you won't know to which industry the stock belongs. The probability to belong to the good, mediocre, or bad industry is equal, i.e. 33%.

Please see the overview table below.

Importantly, in each stage, you will observe the same stock during the whole stage. The dividends of the stock are independent from period to period, but come from the same distribution.

Asset	Probability of industry	Industry	Possible outcomes per period	Probabilities for outcomes
Stock	1/3 (33%)	Good industry	20 EUR - 5 EUR	70% 30%
	1/3 (33%)	Mediocre industry	20 EUR - 5 EUR	50% 50%
	1/3 (33%)	Bad industry	20 EUR - 5 EUR	30% 70%
Bond	-	-	6 EUR	100%

That is, the industry of the stock is the same during the whole stage.

If you decide to invest in the bond, each period you will earn 6 EUR for sure.

During each stage, you accumulate your investment outcomes from investing in the stock or bond. These will be added to your initial endowment of 35 EUR.

The stock evaluation depends on what kind of stock outcomes you have already observed. Please refer to the overview table: The initial probability of the stock to pay a positive outcome is 50%, without any doubt. After observing a series of positive outcomes, you might believe that the probability increased to 65%. Yet, how much you trust your ability to come up with the correct probability estimate that the stock pays a positive outcome might vary.

[*Information provision in the other treatments varied according to the number and size of categories. In the next section you find the overview tables with the relevant information.*]

Post-questionnaire

At the end of the experiment, we will ask you some personal questions. Note that all answers will be treated confidentially and will be analyzed anonymously.

A.2 Information Provision Across Treatments

Figure 4.1: Overview Disaggregated condition

Asset	Probability of industry	Industry	Possible outcomes per period	Probabilities for outcomes
Stock	1/6 (17%)	Very good industry	20 EUR - 5 EUR	75% 25%
	1/6 (17%)	Good industry	20 EUR - 5 EUR	65% 35%
	1/6 (17%)	Good - mediocre industry	20 EUR - 5 EUR	55% 45%
	1/6 (17%)	Mediocre - bad industry	20 EUR - 5 EUR	45% 55%
	1/6 (17%)	Bad industry	20 EUR - 5 EUR	35% 65%
	1/6 (17%)	Very bad industry	20 EUR - 5 EUR	25% 75%
Bond	-	-	6 EUR	100%

Figure 4.2: Overview Broad condition

Asset	Probability of industry	Industry	Possible outcomes per period	Probabilities for outcomes
Stock	80%	Good industry	20 EUR - 5 EUR	70% 30%
	10%	Mediocre industry	20 EUR - 5 EUR	50% 50%
	10%	Bad industry	20 EUR - 5 EUR	30% 70%
Bond	-	-	6 EUR	100%

Figure 4.3: Overview Narrow condition

Asset	Probability of industry	Industry	Possible outcomes per period	Probabilities for outcomes
Stock	10%	Good industry	20 EUR - 5 EUR	70% 30%
	10%	Mediocre industry	20 EUR - 5 EUR	50% 50%
	80%	Bad industry	20 EUR - 5 EUR	30% 70%
Bond	-	-	6 EUR	100%