How to Overcome Correlation Neglect?[a]

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Abstract

By sampling. In two laboratory experiments, we vary how correlation is presented in an investment task. In a descriptive treatment, where participants directly get probabilities for all possible outcomes of a joint return distribution, we confirm the common finding that investors neglect correlation, keeping their diversification decision constant even if they notice changes in correlation. However, when participants sample returns from the same joint distribution, they diversify more when correlation decreases. In our first experiment, where we use only four prospects for the two risky assets, respectively, this finding is robust to sampling numerical returns or graphical bar chart returns. When we use a more realistic continuous return distribution, participants only diversify more at lower correlations after graphical sampling. Hence, graphical sampling helps overcome correlation neglect.

Keywords: Biased Beliefs, Dependence, Investment Decisions, Correlation Neglect, Diversification, Risk Taking

JEL Classification Numbers: C91, G02, G11.

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1 Introduction

CORRELATION, *n. The extent to which securities or financial assets tend to move in tandem. Those who flatter themselves on being brilliant enough to buy assets that all go up at once should remember that, sooner or later, these highly correlated assets may all go down at once, too. If one asset has an above-average - or below average - return and so does the other, they are said to be "positively" or highly correlated. If one has a higher return while the other is lower and vice versa, they are "negatively" correlated. If a higher return on one is associated with either a higher, lower, or average return on the other, then they are uncorrelated. Diversifying is most efficient and powerful when assets in a portfolio are not highly correlated. However, because that always requires owning some assets that will underperform others - rather than chasing whatever is hot at the moment - it will forever be unattractive to most investors.*

Jason Zweig, ***The devil's financial dictionary.***

Households make various mistakes when making their investment decisions. They act extremely risk averse and do not participate in equity markets despite a large equity premium (Campbell (2016);van Rooij, Lusardi, and Alessie (2011)). And even if they participate, they find it very difficult to build portfolios that match their preferences and they can be easily influenced by irrelevant factors of the decision-making environment; they take on more risk than they need by holding underdiversified portfolios through a small number of different assets in their portfolio or by concentrating their investments on familiar assets, in their home or local market (Bekaert, Hoyem, Hu, and Ravina (2016); Benartzi (2001); Grinblatt and Keloharju (2001); Lewis (1999)). One potential reason for this behavioral pattern is that investors simply do not understand the benefit of diversification (Reinholtz, Fernbach, and de Langhe (2016)). Efficient portfolio theory (Markowitz (1952)) has shown that diversification can be achieved through a combination of assets, whose returns are nonperfectly correlated. The free lunch in investment, namely to reduce overall portfolio risk while keeping return expectations constant, is to invest into assets that increase in value when others in your portfolio decrease in value. Several studies have, however, shown, that investors tend to ignore correlations between assets. Kroll, Levy, and Rapoport (1988) were the first to document this correlation neglect in the financial domain; participants in their experiment were asked to allocate an endowment between assets, where only the correlation between asset was varied between participants (from -0.8 to 0.8); they found that allocation was not affected by the treatment. This finding was also replicated in later studies (e.g., Eyster and Weizsäcker (2011); Kallir and Sonsino (2009)): subjects neglect correlations in their allocation decisions, even if it could be shown that they generally noticed the structure of or the changes in co-movement.

So how to overcome correlation neglect? Recent literature has provided strong evidence that personal experiences are an important driver of investors' risk taking; risk perception and expectations are particularly influenced by experienced market returns over the life-time (e.g., Malmendier and Nagel (2011)), personal or peer investment outcomes (e.g.,Kaustia and

Knüpfer (2012); Strahilevitz, Odean, and Barber (2011); Kaustia and Knüpfer (2008)), experiences in their local environment (e.g., Laudenbach, Loos, and Pirschel (2016)) or the experience of adverse labor market conditions (e.g., Knüpfer, Rantapuska, and Sarvimäki (2016)). In the experimental literature, studies have shown that experiences can also be generated in an artificial way, which can be effectively used to inform investors about potential risks. The idea is to enable investors to experience the return distribution with the help of a random sampling of possible returns. Several studies on sampling and risk taking have shown that providing subjects with information about risk in an experience-based manner, for example with the help of a simulation, as compared to a descriptive way, has the potential to increase the general understanding of risk and leads to more consistent investment decisions (e.g., Hertwig, Barron, Weber, and Erev (2004), Abdellaoui, L'Haridon, and Paraschiv (2011), and Kaufmann, Weber, and Haisley (2013)).

In this paper, we analyze whether this way of presenting information to investors also has the potential to overcome correlation neglect in financial decision making. So far, different ways to depict information on correlation between two assets have not been explicitly tested. We conduct two laboratory experiment, where we analyze the influence of descriptive and experience based presentation formats on the influence of allocation changes as a response to an in- or decrease in correlation between eligible assets. For our descriptive treatments, we use a design comparable to Kroll, Levy, and Rapoport (1988) or Kallir and Sonsino (2009), who communicate riskiness via probability statements, which we present numerically (Experiment I and II) or graphically (Experiment II). More precisely, subjects are shown all potential joint return states of assets 1 and 2 and the respective frequency of occurrence. For our experience-based treatments subjects are informed with the help of an experience sampling procedure. More specifically, they are shown draws of joint returns of asset 1 and 2 based on the underlying distribution. To induce experience sampling we use two different formats in both experiments, that have been used in the literature, but not been tested against each other so far. In line with Hertwig, Barron, Weber, and Erev (2004) returns of both assets are expressed in outcomes in the experience numerical treatments, e.g. 15% for asset 1 and −6% for asset 2. In the experience graphical treatment, we use the design of Kaufmann, Weber, and Haisley (2013), where the same information is presented with the help of bar charts. We additionally use this design, as the authors were able to show that their experience sampling procedure leads to a better understanding of the risk-return framework relative to a classical descriptive presentation format. We run two laboratory experiments with a total of 691 students at the Frankfurt Laboratory for Experimental Economic Research. Subjects in both experiments are randomly assigned to one of the presentation format treatments (between-subject design). In two investment decisions, subjects have to allocate an endowment between two assets that are positively correlated in the one and negatively correlated in the other decision, keeping anything else

equal. The order of positive and negative correlation condition is counterbalanced. Asset 1 and 2 are constructed in a way that asset 2 should only be selected due to its diversification potential. Both experiments differed in the complexity of the return distribution of the risky assets involved. After each allocation decision participants are asked detailed questions about their perception about the dependence between the two assets. Kallir and Sonsino (2009) stated in their study that participants realize shifts in correlation, even if they do not change their allocation as a response.

Based on the literature we test the following hypotheses on the effects of presentation format on asset allocation (H_{11} and H_{12}) (Choice) and correlation perception (H_{21} and H_{22}) (Beliefs):

H_{11}: Investors do not diversify more when correlation decreases if asset returns are presented in a descriptive way.

H_{12}: Investors do diversify more when correlation decreases if asset returns are presented in a experience-based manner.

H_{21}: Investors are able to perceive changes in correlations througout all presentation formats.

H_{22}: Perceptions are more accurate if asset returns are presented in an experience-based manner.

We are able to replicate findings from the literature. In line with Eyster and Weizsäcker (2011), Kallir and Sonsino (2009), as well as Kroll, Levy, and Rapoport (1988), we can confirm the common finding that investors neglect correlation in our descriptive treatments: participants do not diversify more when correlation decreases. Once we use the novel experience-based manner of information presentation, they diversify more when correlation decreases. In our first experiment, this finding is robust to sampling numerical returns or graphical bar chart returns. It is not driven by the time spent looking at the return information and holds controlling for potential sampling errors or recency. When we use a continuous return distribution of the risky assets involved, participants only change allocations as a response to changes in correlation in the graphical experience sampling treatment. Hence, graphical sampling helps overcome correlation neglect.

If we analyze participants' beliefs about dependence, evidence is mixed. First of all, we confirm our Hypothesis H_{21}, that investors are able to perceive changes in correlations throughout all presentation formats independent of the complexity of the return distribution. With regard to differences between presentation formats, we are able to show that participants are more accurate in answering questions about the correlation and the co-movement between the two assets in both experience treatments in Experiment I (simple asset case). Once return distributions get more complex in Experiment II, we find that differences in perception of dependence are not robust. We especially do not find any evidence that participants'

beliefs are more accurate about dependence in the graphical compared to the numerical experience treatment. Therefore, differences in the accuracy of beliefs are no explanation for why participants diversify in the graphical, but not in the numerical experience treatments. We therefore believe that correlation neglect is more likely a result of a worse understanding of diversification benefits instead of a result of a worse understanding of the distribution of returns. In health care experiments, graphical representations of risk (as opposed to numerical ones) have been shown to improve patients' decision-making accuracy for example in the the context of cancer treatments (Bogardus et al. 1999). The information given in that context is rather complex. The differences in results between the

rst and the second experiment may hence be driven by the fact that the graphical sampling procedure helps investors to incorporate information into choice once the decision environment gets more complex.

We contribute to the literature in several ways. First, we show a way to overcome correlation neglect and increase diversification in asset allocation decisions. Second, we add to the literature on how to inform investors about risk with the help of experience sampling. The way how risk is communicated to investors gets more and more important in times of private retirement planning and a high number of self-directed investment decisions. With Robo-advice being en vogue, practitioners have already started to provide customers with tools that are intended to support their financial decision-making. Sampling procedures like the risk tool of Kaufmann, Weber, and Haisley (2013), that have already been served as an impulse for real world tools used in banks could easily be enhanced to a two asset-case, where investors can learn about the value of diversification.

2 Experience Sampling and Correlation Neglect: Simple Asset Case

2.1 Experimental Setup

Experimental tasks: To test the influence of presentation format on investment decisions (H_1) and correlation perception (H_2), we use an allocation task similar to previous studies on correlation neglect (e.g., Eyster and Weizsäcker (2011), Kallir and Sonsino (2009)). In both experiments, we ask participants to allocate an endowment of 10'000 € between two risky assets. To define the return distribution of the underlying assets, we adapt the design from Ungeheuer and Weber (2016). Asset 1 has an average return of 5%, while asset 2 offers an average return of only 4%. Asset 2's return is achieved through a shift of asset 1's distribution by 1%, so that all higher moments (e.g. volatility or skewness) are equal across assets. The only reason to select Asset 2 for the portfolio is hence its diversification potential. We choose an allocation decision with only two assets and no risk-free asset to

keep the investment decision as simple as possible.

After a short introduction, participants are informed about the risk-return profile of the two assets. The manner, in which this information is presented, varies between treatments (between-subjects-design, described further in the Presentation Format section). Subjects are then asked how they want to allocate their endowment between the two assets. After the allocation decision they answer questions about the perceived correlation and co-movement of the two assets and about risk and return perceptions of their chosen portfolio. Next, participants have to make a second allocation decision, where everything is kept equal except the correlation between the two assets (counterbalanced within-subject design, described further in the Correlation section). After the allocation decision, subjects are again asked questions about correlation and risk-return perceptions.

Stimuli - Correlation: In order to test, whether participants adapt their allocation to a variation in correlation, every participant has to make two allocation decisions (counterbalanced within-subject-design). The choices differ only in the linear dependence between the two assets. Linear dependence means that the expected value of one asset's return is always linear in the other asset's return, i.e. $E(r_1|r_2) = a + b \cdot r_2$. Correlation is 0.6 in condition 1 and -0.6 in condition 2.[1]. The joint distribution of the returns for both conditions is depicted in Table 1.

[INSERT TABLE 1 ABOUT HERE]

The co-movement between returns is higher in condition 1 (positive correlation) as compared to condition 2 (negative correlation). Normatively, we would expect participants to diversify more once correlation decreases. Figure 1 shows the optimal investment in asset 2 for an expected utility maximizing investor with constant relative risk aversion (CRRA) at relative risk aversion from 0.5 to 10. A decrease in correlation (from 0.6 to -0.6) leads to a higher optimal investment in asset 2. Once again, the only reason for a reasonably risk-averse CRRA investor to invest in asset 2 is to diversify risk. With a decrease in correlation, the diversification potential of asset 2 increases, and hence also the optimal investment in asset 2. Increased relative risk aversion leads to a higher optimal investment in asset 2. The return-difference of 1% between the two assets is selected so that only unreasonably low levels of relative risk aversion lead to the boundary solution of zero investment in asset 2.

[INSERT FIGURE 1 ABOUT HERE]

According to the literature on correlation neglect, we would, however, expect participants to not diversify more if correlation decreases (H_{11}). To test whether this effect is caused by

[1] We chose 0.6 and -0.6 with reference to Ungeheuer and Weber (2016); we do not believe that a change in the exact number of the coefficient would change our results. Kroll, Levy, and Rapoport (1988) used coefficients of (+/-)0.8, while Kallir and Sonsino (2009) exposed subjects to correlation coefficients of (+/-) 1/3 and 2/3

the way the information is presented, we use three different treatments, that vary between subjects.

Stimuli - Presentation Format: Participants are randomly assigned to one of the three treatments (description, experience numerical, and experience graphical). The three treatments differ in the way information about returns is presented. Through all treatments, returns are colored green if positive, and red if negative as is often done with real market data. To link our experiment to the existing studies on correlation neglect, we use a description treatment, where we communicate the riskiness of returns via probability statements (see Kallir and Sonsino (2009) and Kroll, Levy, and Rapoport (1988)). More specifically, subjects are shown one table with all potential joint return states of assets 1 and 2 and the respective frequency of occurrence. The table varies between conditions (positive and negative correlation). In the two experience treatments, subjects are informed with the help of an experience sampling procedure. More specifically, they have to make 60 draws of joint returns of asset 1 and 2 based on the underlying distribution. Subjects know the number of draws from the beginning, as the progress is displayed on the screen, e.g. 'draw 5 out of 60'. To induce experience sampling we use two different formats, that have been used in the literature. In line with Hertwig, Barron, Weber, and Erev (2004) returns of both assets are expressed in numerical outcomes in the numerical experience treatments, e.g. 15% for asset 1 and −6% for asset 2. In the experience graphical treatment, we use the design of Kaufmann, Weber, and Haisley (2013), where the same information is presented graphically with the help of bar charts. For time reasons we did not let participants draw a representative sample of 100 pictures, but made them draw 60 pictures without replacement out of representative sample of 100 return pairs, which hence differed by participants and decision round. This may cause a sampling error, that also has the potential to influence subjects allocation decision (see e.g., Hau, Pleskac, Kiefer, and Hertwig (2008); Fox (2006)). We control for potential sampling error effects later in our analysis. Examples for all three treatments are shown in figure 2.

[INSERT FIGURE 2 ABOUT HERE]

Based on the literature on the general effect of experience sampling on risk taking and investment decisions, we expect a higher allocation into diversification asset 2 in case of negative compared to positive correlation in the experience treatments (H_{12}). We expect the same difference to be insignificant in the description treatment based on the findings on correlation neglect in the literature (H_{12}).

Perception of Dependence: In order to test, whether subjects ignore correlations or simply misunderstand them, we ask questions about general dependence (e.g., 'asset 1 and asset 2 move into ... directions'; 'if asset 1 increases, I expect asset 2 to ...') as well as the exact frequency of co-movement ('if asset 1 increases, I expect asset 2 to increase in ... out

of 100 cases'). Kallir and Sonsino (2009) find that participants realize shifts in correlation, even if they do not change their allocation as a response. We hence expect participants to generally understand a shift in dependence in all treatments (H_{21}). Based on the findings of Bradbury, Hens, and Zeisberger (2015) as well as Kaufmann, Weber, and Haisley (2013), we expect that participants are more accurate in their beliefs about dependence in the experience treatments (H_{22}) compared to the description treatments.

Control variables: After the second decision, participants are asked some additional questions on demographics, financial literacy, and numeracy. Appendix A gives an overview of the outcome variables (Panel A) and control variables (Panel B) collected throughout the experiment.

Payment: Participants are paid in an incentive compatible manner. One of the two investment choices is randomly selected for payoff. To determine the final outcome one random return pair is drawn out of the underlying distribution, multiplied with the shares the participant allocated to the respective assets and divided by 1000. Example: If a subject invested 70% in asset 1 and 30% in Asset 2 and the random draw revealed decision 1 with a return of -6% for A and 15% for B, her payment is: (0.7*10,000*(1-0.06)+10,000*(1+0.15))/1000=10.03. Participants on average received a payoff of 10.37 € for a one-hour experiment including instructions and payment.

2.2 Results

Data and participants: The experiment was conducted in May 2016 at the Frankfurt Laboratory for Experimental Economic Research[2] with 289 participants. The participant pool consists mostly of university students. Summary statistics are reported in Table 2 for all subjects as well as by treatment.

[INSERT TABLE 2 ABOUT HERE]

Participants are on average 22 years old and 70% of them have taken a statistic course, so that the majority should be familiar with the concept of correlations. Note that the experimental randomization worked, as there are no statistically significant differences in personal characteristics between treatments.

Asset Allocation Decisions: Table 3 gives an overview of the share invested in diversification asset 2 by treatment and condition. We would expect participants not to change their allocation in the description treatment in line with correlation neglect (H_{11}). This is exactly what we find - participants invest on average even a (insignificantly) higher amount (33.08%)

[2] The laboratory is a research center at the Faculty of Economics and Business Administration at Goethe University Frankfurt. The software packages Orsee (Greiner (2003)) and z-Tree (Fischbacher (2007)) were used to conduct the experiment.

in asset 2 in the positive compared to the negative (31.02%) correlation condition. In the experience treatments, participants do, however, diversify less in the positive compared to the negative correlation condition, as is optimal for a risk-averse investor. Participants allocate on average 7.37 (10.62) percentage points less in asset 2 in response to correlation changes in the numerical (graphical) experience treatment (H_{12}). Figure 3 depicts the chosen allocation in the framework of an expected utility maximizing investor with constant relative risk aversion (CRRA). The graph shows that the within-subject differences in implied risk aversion resulting from the average chosen allocation to asset 2 are much larger in the description treatment as compared to the experience treatments. Hence, the experience treatments lead to investment decisions that are much more in line with normative theory in the sense of the optimal diversification decision according to Markowitz.

[INSERT TABLE 3 ABOUT HERE]

[INSERT FIGURE 3 ABOUT HERE]

Looking at subjects' allocation in a between-subject design, we find that the degree of diversification in response to correlation-changes increases significantly from description to experience treatments (H_{12}). There is no statistically significant increase from the numerical to the graphical experience treatment.

Next, we analyze the influence of presentation format on investment decisions in a random effects regression model with the share invested in asset 2 as the dependent variable. We run random effects regressions to take participant-specific effects into account. Since the treatment is orthogonal to participant characteristics, random effects regressions are justified. This is also why adding control variables does not change treatment effect estimates.[3] Specification (1) of Table 4 confirms our previous results. Participants invest an average of 31% into asset 2 in the description treatment in the negative correlation condition. For participants in the experience treatments, this share is generally higher and, more importantly, significantly increases with a change from positive to negative correlations.

[INSERT TABLE 4 ABOUT HERE]

Next, we analyze some alternative factors that may drive our results, but are not based on the difference in the presentation format itself. In a first test, we exclude participants, who might not have understood the general diversification potential of asset 2. Asset 2 has a lower return and the same marginal distribution compared to asset 1; it should thus only be interesting because of its diversification potential up to a weight of 50%. In specification (2)

[3] In unreported tests we find that control variables do not significantly predict investment decisions. Generally, if we add gender, risk attitude, interest in financial markets to our regression, we only find a marginally significant negative effect of interest in financial markets on the decision to diversify.

we hence exclude investors that invest more than 50% into asset 2 and find that results are robust to the exclusion of these participants. Results get a little weaker for the numerical experience treatment and stay similar for the graphical experience treatment if we restrict the sample to participants who have taken a statistic course or report to be interested in financial markets (results are not reported).

[INSERT TABLE 5 ABOUT HERE]

Every participant in our experiment has to make two investment choices, the first in the low correlation condition, the second in the high correlation condition, or vice versa. One could argue that her second decision is influenced by the first, as subjects already know more about the decision making process and hence perceive or collect the information presented differently. Thus, we restrict our sample to subjects' first decision only in specification (3). Results hold and reveal that the effect of presentation formats is present within (specification (1)) as well as between subjects (specification (3)). Nevertheless, subjects may learn over the course of the experiment. In specification (4) we test whether subjects show a systematically different allocation behavior in the second as compared to the first decision round. We do, however, not find a learning effect. This is in line with the result of Kroll, Levy, and Rapoport (1988) who also do not find a session-to-session change in allocation.

Fox and Hadar (2006) invoke that differences in choice comparing descriptive and experience-based presentation formats may also be explained by recency effects or sampling error. In specification (2)-(4) of table 4, we therefore include the last (specification 2) or the first correlation (specification 3) as well as the first and last returns, that participants in the experience sampling conditions observed. If anything, we find an effect of whether the first correlation seen is positive. We do, however, still find that participants significantly respond to shifts in correlation in the experience sampling treatments. We have also tested alternative specifications, where results are available on request: Results are also robust to including all, as well as the first or the last five correlations or fractions of comovement realized as well as to including the realized number of observations with at least one negative return.

One concern that always occurs with experience sampling is sampling error. Participants in our experience treatments do, in contrast to participants in the description treatment, not get a representative sample of the distribution, as they only sample 60 observations from a sample of 100 representative observations. On average, participants in both experience treatments sampled the objective mean return of 5% for asset 1 and 4% for Asset 2, but with a standard deviation of 1.11% and 1.04%, respectively. The resulting average correlation is +0.6 in the positive, and -0.6 in the negative correlation, but with an interval of -0.3 to -0.8 and 0.3 to 0.8, respectively. Figure 4 shows the distribution of realized correlations across treatments. We see that there is indeed variation in the correlation realized due to the randomization of 60 out of 100 potential draws by participant. In specification (5) of

table 4 we limit our analysis to participants in the experience treatments, whose sampling error is small, namely who realized a correlation between -0.65 and -0.55 in the negative correlation and between 0.55 and 0.65 in the positive correlation condition. Results also hold for this specification, showing that the effect cannot be explained by sampling error.

[INSERT FIGURE 4 ABOUT HERE]

One alternative explanation is that the effect is not driven by the sampling itself, namely the way the information is presented, but rather by the time needed to collect this information. Generally, subjects can take as long as they want, but the minimum time needed in the description treatment is lower as compared to the experience treatments, as participants have to view one picture in the former and 60 pictures in the latter case. Panel A of Table 6 shows the average time spent for viewing the information about asset returns by treatment. The time spent in both experience treatments, 110 seconds in the numerical 106 seconds in the graphical treatment, is significantly higher as compared to the 75 seconds spent in the description treatment (t-values of 5.76 and 4.91 respectively).

[INSERT TABLE 6 ABOUT HERE]

There is no significant difference between the numerical and the graphical experience treatment. Panel B of table 6 shows the allocation to asset 2 separately for participants, who spent above and below the median time in order to collect information about asset returns. Results look very similar for both subsamples; the time spent with the information does not drive the effects of presentation format. We also do not find significant differences in the time spent dependent on whether participants face the positive or the negative correlation condition. Figure 5 shows the time spent per picture by treatment and condition.

[INSERT FIGURE 5 ABOUT HERE]

We would generally expect participants to spend more time in the first as compared to the second decision round, as they get more familiar with the environment and therefore need less time to process information. Interestingly, participants in the experience treatments spent more time in the first compared to the second round while the effect is reversed, however insignificantly, for participants in the description decision. This finding could be interpreted as a first hint of subjects feeling more confident in their decision in the experience treatments. After each decision we have asked participants directly about their confidence; subjects indeed report a (marginally) significantly higher confidence in the graphical experience treatment (4.11) as compared to the description treatment (4.38). There is no significant effect between the numerical experience and the other two treatments. Furthermore, our results hold if we weight observations in the experience sampling treatments by

viewing times, namely the time the participants looked at each picture. Again, results are available on request.

Overall, we find a robust effect of presentation format on the response to correlation changes in asset allocation. Kaufmann, Weber, and Haisley (2013) as well as Bradbury, Hens, and Zeisberger (2015) suggest that experience sampling can improve participants' understanding of the risk-return-framework. In the next section, we analyse, whether participants in our experiment overcome correlation neglect due to a better perception of correlations.

Perception of Dependence: Table 7 reports participants' beliefs about dependence. In summary, we find that participants move their answers to the right direction as a response to correlation changes in all treatments (H_{21}). The effect is, however, not robust in the description treatment (only statistically significant differences in one of the three questions). In both experience treatments, participants clearly note the shift in dependence. More importantly, the findings lend support to hypothesis H_{22}: participants are more accurate about dependence in the experience treatments compared to the description treatments. In more detail, participants (correctly) believe dependence increases from the negative to the positive correlation condition. The exact questions asked are shown in the table and listed in Appendix X. Panel A1 of Table 7 shows that the majority of participants in the numerical (54%) and the graphical experience treatment (67%) note that asset 1 and 2 move in opposite directions in the negative correlation condition (correlation of -0.6), while this is only the case for 39% of participants in the description treatment. In positive correlation treatment (correlation of +0.6), the majority of participants in the the numerical (71%) and the graphical experience treatment (62%) note that asset 1 and 2 move together, while this is only the case for 21% in the description treatment. The increases of mean beliefs are statistically significant for both experience treatments. If we rephrase the question and ask participants what happens to asset 2 if asset 1 increases (Panel A2), results also turn significant in the description treatment (1.79 in the negative versus 1.99 in the positive correlation condition), but the effect is much stronger in the experience treatments. Panels B depicts participants beliefs about the frequency of co-movement. Results reveal that participants again note the change in the frequency of co-movement in the description treatment, but effects are only statistically significant in the experience treatments. Panel C summarizes results in an overall dependence score, where we add up the standardized answers of the three questions.[4] Again, results provide support for our hypothesis (H_{22}): participants are able to form more accurate beliefs in the experience sampling treaments as compared to the description treatment.

[INSERT TABLE 7 ABOUT HERE]

[4]Before adding up answers we subtract the mean score and divide by the standard-deviation of scores for each question.

Perception of Portfolio Risk: Next, we analyze whether participants accurately understand portfolio risk. Eventually, diversification is valuable because it reduces portfolio risk. Reinholtz, Fernbach, and de Langhe (2016) show that participants in their experiment (wrongly) believe that diversification increases portfolio volatility, which leads to portfolios that mismatch investors' risk preferences. So far, we have only analyzed participants' beliefs about dependence: In Table 7 we show that particpants can accurately answer questions about dependence. When correlation is negative (positive), they understand that asset 2 is more likely to increase (decrease) in value when asset 1 decreases in value. Hence, they understand the effects of correlation on an state-by-state basis. Does this mean that they can properly use their knowledge about correlations to estimate overall portfolio risk? To find out, we ask participants to estimate the probability of a loss of their overall portfolio. We report results in Table 8. The effect of changes in correlation on the true probability of loss is strong for the average participant's portfolio decision. For the description treatment, the true probability of loss increases by over 17% from the negative to the positive correlation condition. For the experience numerical (graphical) treatment, the increase in true probability of loss is even larger at over 21% (over 24%). However, participants' estimate for the probability of loss does not increase by more than 1% from the negative to the positive correlation treatment and these increases are statistically insignificant. The estimated probability of loss even decreases by 5% for the experience numerical treatment (statistically significant at the 10% level). Hence, participants are not able to use their accurate understanding of correlations to properly assess portfolio risk.

[INSERT TABLE 8 ABOUT HERE]

This result does not contradict our previous finding that correlation neglect disappears when sampling is used as a presentation format. Table 7 clearly shows that participants understand dependence on a state-by-state basis in the experience treatments. Their investment decisions in Table 3 are in line with this accurate understanding of dependence. The misestimation of portfolio risk in Table 8 just shows that participants are not able to aggregate correct state-by-state beliefs to the portfolio level. It is not necessary to perform the challenging task of aggregating individual assets' return distributions into the portfolio's return distribution (Reinholtz, Fernbach, and de Langhe (2016)) in order to adequately react to changes in correlation. Understanding what happens to asset 2 when asset 1 increases in value is enough to understand the value of diversification.

Overall, we find that sampling helps to overcome correlation neglect in asset allocation decisions and our results are robust to excluding participants with unreasonable levels of diversification, using a pure between-subjects design (results from the first round only) or controlling for sampling error as well as decision times. One question that remains unanswered is, whether the positive effect of experience sampling also holds in a more realistic

scenario with a more complex return distribution. In addition, it is not quite clear, whether the higher diversification is driven by a better understanding of the dependence itself (beliefs) or by understanding of the benefits of diversification (in the sense of risk reduction and choice). Hence, we conduct a second experiment using a more realistic return distribution.

3 Experience Sampling and Correlation Neglect: Complex Asset Case

3.1 Experimental Setup

Experimental task: In Experiment II, we again ask participants to allocate an endowment of 10'000€ between two risky assets. We increase, however, the complexity of the return distribution in order to depict a more realistic scenario, but keep general return parameters equal: like in the first experiment, asset 1 has an average return of 5%, while asset 2 offers an average return of only 4%. Returns are now normally distributed and the volatility of both assets is set to 13 percent. The general experimental flow as well as the questionnaires are also kept equal to the procedure in Experiment I.

Stimuli - Correlation and Presentation Formats: Like in Experiment I, every participant had to make two allocation decisions and choices differ only in the linear dependence between the two assets (correlation of 0.6 in condition 1 and -0.6 in condition 2).

Participants are randomly assigned to one of four different presentation formats: description, description graphical, experience numerical, and experience graphical. Using normal return distributions for the risky assets in Experiment II, we have to change the design of the pictures in the following way:

In our baseline description treatment, we again communicate the riskiness of returns via probability statements. As returns are now continuous, we use ranges in order to provide these statements. More specifically, subjects are shown one table with potential joint return ranges of asset 1 and 2 and the respective frequency of occurrence (see Graph A of figure 6). In order to ease understanding, we include reading examples like the following: *In 10 out of 100 cases asset 1 has an annual return between -5% and 5%, while asset 2 at the same time has an annual return between 5% and 15%.* Tables again vary between conditions (positive and negative correlation).

As an alternative descriptive treatment, we also introduce a graphical way to communicate the riskiness of the two assets. In this graphical description treatment subjects face a three-dimensional bar chart, where the length of the bars illustrates the frequency of occurrence of the joint return ranges (see graphs B of figure 6). We again include reading examples in order to ease understanding.

In the two experience treatments, subjects are informed with the help of experience sam-

pling procedures as in Experiment I. The pictures provided do not look different with regard to their design in comparison to Experiment I, the variation in different outcomes that can be observed is of course much higher. Therefore, we use a stratified sampling method in order to reduce the sampling error when generating the different 60 pictures for each participant in both of the two experience treatments. Stratification in this context means that we divide the distribution's support into 60 equally likely subranges before sampling. Participants are then provided with one return pair out of each subrange in random order.

[INSERT FIGURE 6 ABOUT HERE]

Payment: The payment procedure is the same as in the previous experiment: one of the two investment choices is randomly selected for payoff. Participants on average received a payoff of 10.27€ for a one-hour experiment including instructions and payment.

3.2 Results

Data and participants: The experiment was conducted in November and December 2016 at the Frankfurt Laboratory for Experimental Economic Research with 402 participants. Participants, who had already taken part in Experiment I were excluded from the subject pool. Summary statistics are reported in Table 9. Personal characteristics are comparable to those reported in Experiment I.

[INSERT TABLE 9 ABOUT HERE]

Asset Allocation Decisions: When we look at the the share invested in diversification asset 2 by treatment and condition in Table 10, we are able to replicate our main effect comparing decisions in the baseline description and the graphical experience treatment: participants again do not to change their allocation in the description treatment in line with correlation neglect (H_{11}), but diversify significantly less in the positive compared to the negative correlation condition in the graphical experience sampling group. The difference in difference between the two groups is smaller compared to Experiment I, but still significant at the 10% level and this effect also holds in a random effects regression model (not reported).

[INSERT TABLE 10 ABOUT HERE]

Looking at the remaining two treatments, we find that subjects do neither incorporate correlation considerations into choice in the graphical description treatment, nor in the numerical description treatment. Graphical representations of risk (as opposed to numerical ones) have been shown to improve patients' decision-making accuracy in the context of different breast cancer treatments (Bogardus et al. 1999). The information given in that context is rather complex. The differences in results between the first and the second experiment

may hence be driven by the fact that the graphical sampling procedure helps investors to incorporate information into their choice, even if the decision environment gets more complex, whereas the numerical description treatment does not.

With regard to the three-dimensional graphical description treatment, we, however, find the opposite effect: participants diversify more in the positive compared to the negative correlation condition. One reason might be that three-dimensional graphs are a presentation format, which subjects are unfamiliar with. We take the fact, that a relatively large fraction (23%) of participants allocated their endowment equally across the two assets as first evidence underlying this idea.

Generally, effects are weaker compared to the first experiment. One potential explanation is that the continuous return distribution makes the variation in observed frequencies of comovement smaller, even though the variation in correlations across conditions remains the same (-0.6 and +0.6). Figure 7 depicts realized correlations and comovements for Experiment I and II. While realized correlations for the experience treatments are comparable between the two experiments, graphs reveal that there is a clear difference in realized comovements.

[INSERT FIGURE 7 ABOUT HERE]

While the fraction of realized comovement varies between 0.2 and 0.8 in Experiment I (dependent on the correlation condition), it varies between 0.36 and 0.72 in Experiment II, making the stimulus around 40% weaker.[5] Overall, we find a robust effect of graphical experience sampling on the response to correlation changes in asset allocation. We can, however, not replicated the effect for numerical sampling. In the next section, we analyze, whether differences in choice between Experiment I and II are driven by differences in perception of dependence, once the decision environment gets more complex.

Perception of Dependence: Table 11 reports participants' beliefs about dependence in Experiment II. In summary, we find, in line with results from Experiment I, that participants move their answers into the right direction as a response to correlation changes in all treatments (H_{21}). Therefore, the average answers to questions about beliefs in the graphical description treatment are correct and statistically significant from low to high correlation. Hence, the differences in diversification decisions cannot be explained by incorrect beliefs about dependence. This is in line with Kallir and Sonsino (2009), who find that subjects neglect correlations in their allocation decisions, even if they generally noticed the structure of or the changes in co-movement.

Between treatments, differences in perception of dependence are not robust. Dependent on which dependence question we ask, beliefs are slightly more accurate in the experience treatments compared to the description treatments (see Panel A2 of table 11), but for the

[5] Measuring the strength of the stimulus based on comovement instead of correlation can be motivated by Ungeheuer/Weber (2016): They find that subjects diversify based on frequencies of comovement rather than correlations.

overall dependence question (see Panel A1 of table 11) and the comovement question (see Panel B of table 11)), we do not find any significant differences between treatments.

[INSERT TABLE 11 ABOUT HERE]

We especially do not find any evidence that participants' beliefs are more accurate about dependence in the graphical compared to the numerical experience treatment. Therefore, differences in the accuracy of beliefs are no explanation for why participants diversify in the graphical, but not in the numerical experience treatments. We therefore believe that correlation neglect is more likely a result of a worse understanding of diversification benefits instead of a result of a worse understanding of the distribution of returns.

4 Conclusion

This paper shows that using a (graphical) experience sampling procedure to inform investors about the correlation of returns of two assets as opposed to a descriptive way has the potential to overcome the often documented correlation neglect in asset allocation decisions. Until now, regulatory agencies focus strongly on the risk communication of single assets to make, for example, investment funds comparable with the help of standardized risk documents (e.g., the key investor information document within the European Union). Banks, investment firms and especially new FinTech start up firms have, however, build first steps in the direction of a portfolio-based allocation approach and have already proven the applicability of decision-making tools within or aside from the advisory process. Sampling from (simulated or historical) return distributions seems to help investors in reaching optimal investment decisions and such a sampling procedure can be easily implemented and provided on a bank's website. The implementation of a self-running education tool can overcome the potential disadvantage that informing clients with the help of experience sampling may be a little more time consuming as compared to handing out a descriptive fact sheet.

In addition, the idea of letting participants experience relationships between certain outcomes may be of importance in several areas. The necessity to educate or help people to understand correlations is not unique to the financial domain. The fact that observed dependence may lead to a better understanding of risks than just displaying probabilities should also be tested in future research. For example, the health industry has similar problems in explaining and communicating risk in an understandable way to their patients. Sample procedure may also serve as a helpful tool in this domain; e.g. telling people that smoking cigarettes reduces their life expectancy by 10 years may have a different effect than having them draw ages of death from a distribution of smokers vs. non-smokers.

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Figure 1: Experiment 1: CRRA-Optimal Investment in Diversification Asset 2

For each of the conditions, this figure displays the investment in asset 2 out of $10'000$ € that maximizes the expected CRRA-utility at levels of relative risk aversion between 0.5 and 10. Conditions 1 and 2 exhibit correlations between the two assets of -0.6 and 0.6, respectively. The investment is restricted to be in the closed interval between 0 and 1 and it is assumed that the remaining funds are invested in asset 1.

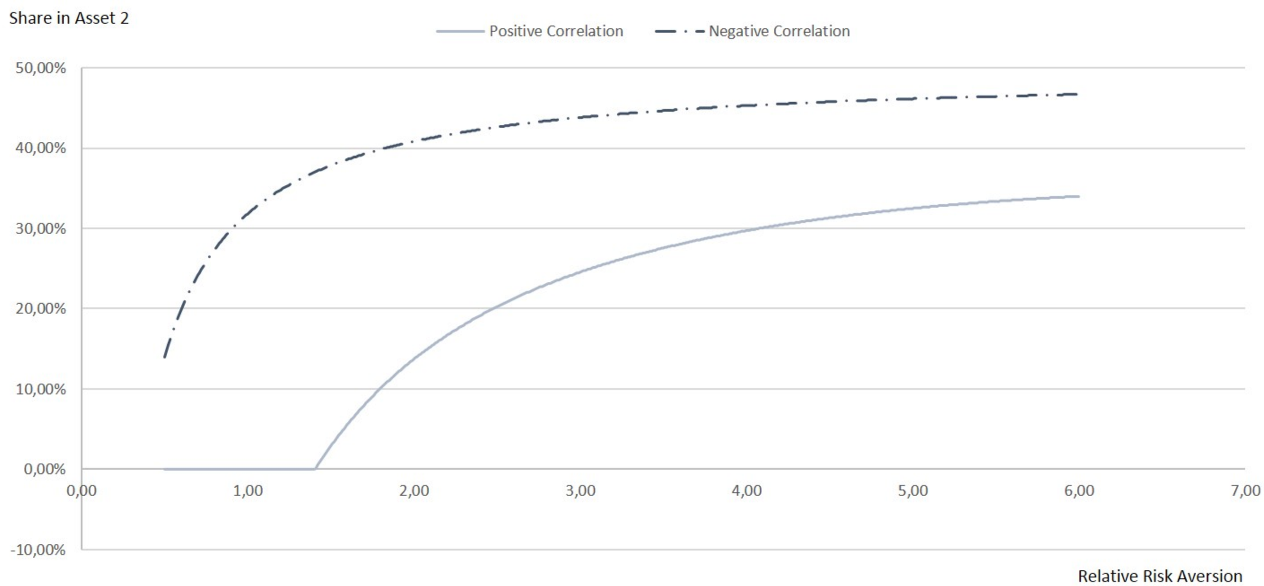


Figure 2: : Illustrative presentation formats of different treatments

These graphs are illustrative examples for the information shown to participants in the experiment. Graphs in the first row show the information presented in the description treatment, for both - negative (left hand side) and positive (right hand side) correlation condition; the second row depicts two example pictures from the numerical experience and the graphical experience treatment respectively. Note that treatments were held constant between participants, but every participant faced both conditions; the order of conditions was counterbalanced. Returns are displayed in green (red) when positive (negative). The labels are in German. Translations: 'Anlage X (durchschnittliche Rendite pro Jahr = y%)' means 'Asset X (average return per year = y%)'. 'zu erwarten in ... von 100 Fällen' means 'to be expected in ... of 100 cases'.'Rendite Simulation für Anlage 1 & 2' means 'Return-Simulation for Assets 1 & 2'.

A) Description

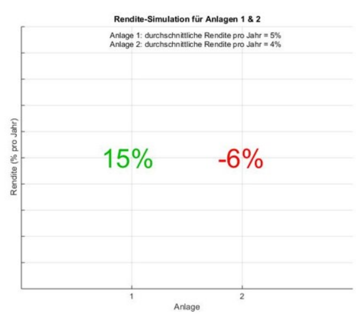
Anlage 1: durchschnittliche Rendite pro Jahr = 5%
Anlage 2: durchschnittliche Rendite pro Jahr = 4%

Rendite (% pro Jahr)		zu erwarten in ... von 100 Fällen
Anlage 1	Anlage 2	
-25%	-26%	1
-25%	34%	4
-5%	-6%	9
-5%	4%	36
15%	-6%	36
15%	14%	9
35%	-26%	4
35%	34%	1

Anlage 1: durchschnittliche Rendite pro Jahr = 5%
Anlage 2: durchschnittliche Rendite pro Jahr = 4%

Rendite (% pro Jahr)		zu erwarten in ... von 100 Fällen
Anlage 1	Anlage 2	
-25%	-26%	4
-25%	34%	1
-5%	-6%	36
-5%	4%	9
15%	-6%	9
15%	14%	36
35%	-26%	1
35%	34%	4

B) Experience Numerical



C) Experience Graphical

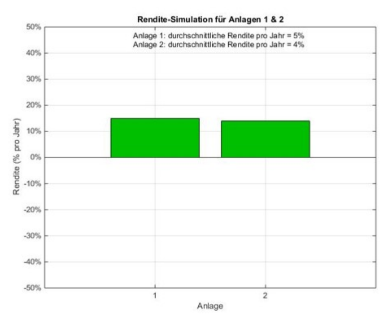


Figure 3: CRRA-Investment in Diversification Asset 2 by Treatments

For each of the conditions, this figure displays the investment in asset 2 out of 10′000 € that maximizes the expected CRRA-utility at levels of relative risk aversion between 0.5 and 10. Conditions 1 and 2 exhibit correlations between the two assets of -0.6 and 0.6, respectively. The investment is restricted to be in the closed interval between 0 and 1 and it is assumed that the remaining funds are invested in asset 1. In addition the average allocation as well as the associated risk aversion is plotted for each of the treatments (description, experience numerical, and experience graphical). The arrows below the graph indicate the average difference of risk aversion by participants for each treatment. From a rational CRRA investor's perspective, differences should be zero.

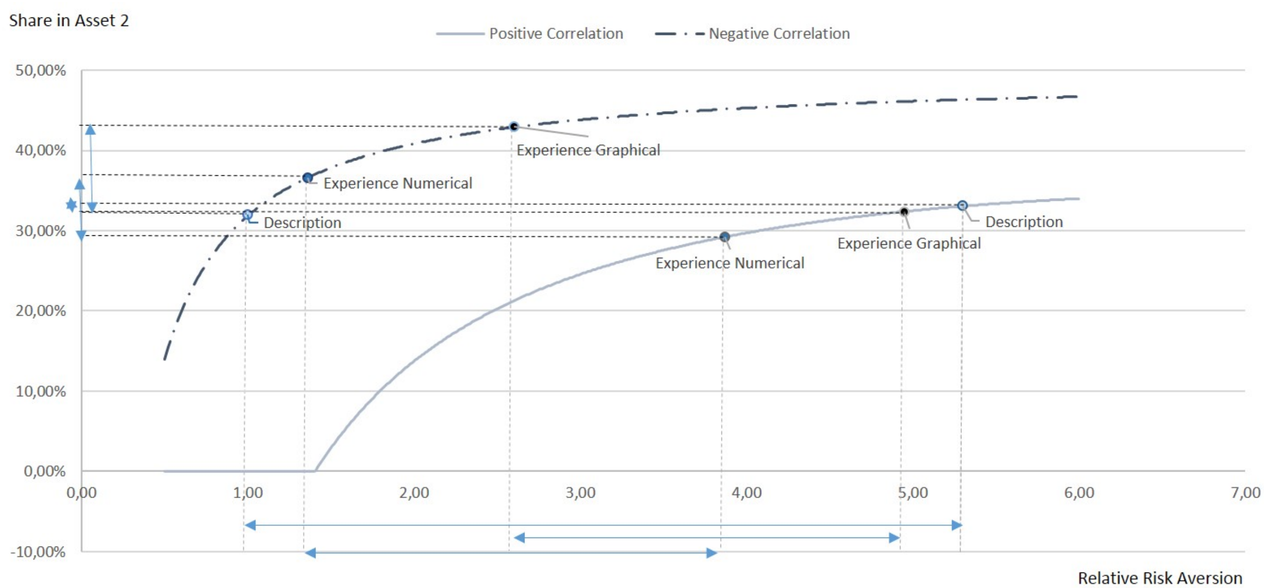


Figure 4: Realized Correlation by Presentation Format

For each of the treatments, this figure displays the fraction of realized correlations for all participants. Participants in the description treatment always viewed a representative picture of the underlying distribution and hence all realize a correlation of 0.6 for the first and -0.6 for second condition or vice versa. Participants in the experience treatment view 60 (out of 100) pictures for each decision. The realized correlation could hence be lower or higher than 0.6 or -0.6 respectively.

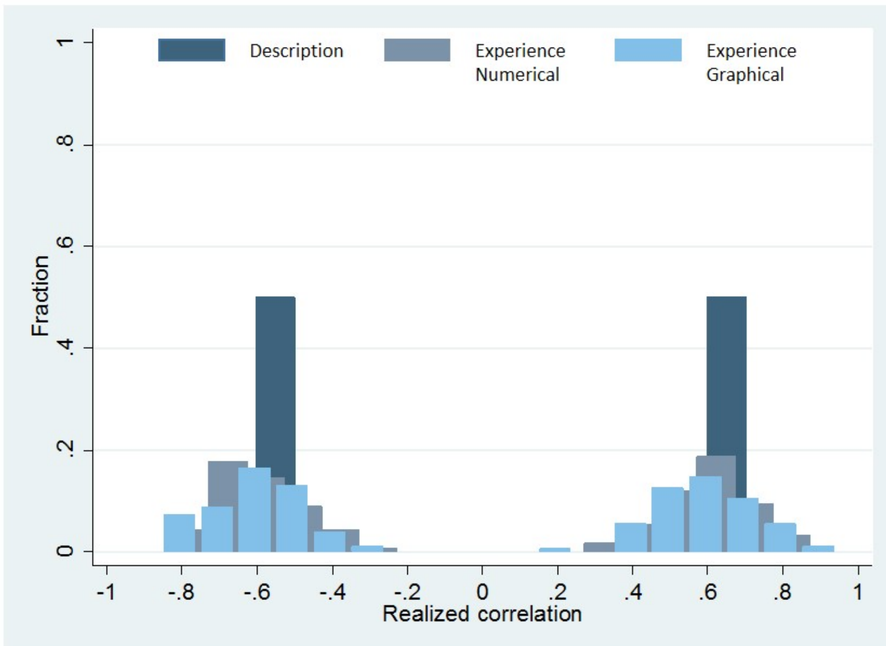


Figure 5: Presentation Format and Attention Time

For each of the treatments and conditions, this figure displays the number of seconds subjects looked on average on each of the pictures shown. There was one picture in the description condition and 60 pictures in the experience numerical and experience graphical, respectively. The first bar reflects the time spent with the first picture, the second one the time spent with the second picture and so on. Results are shown for the first round only.

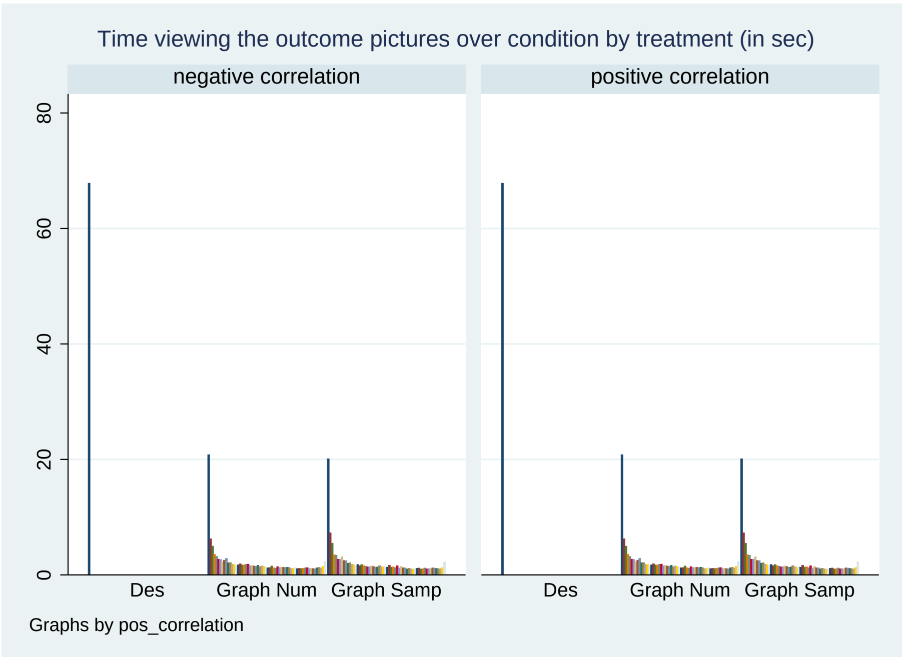
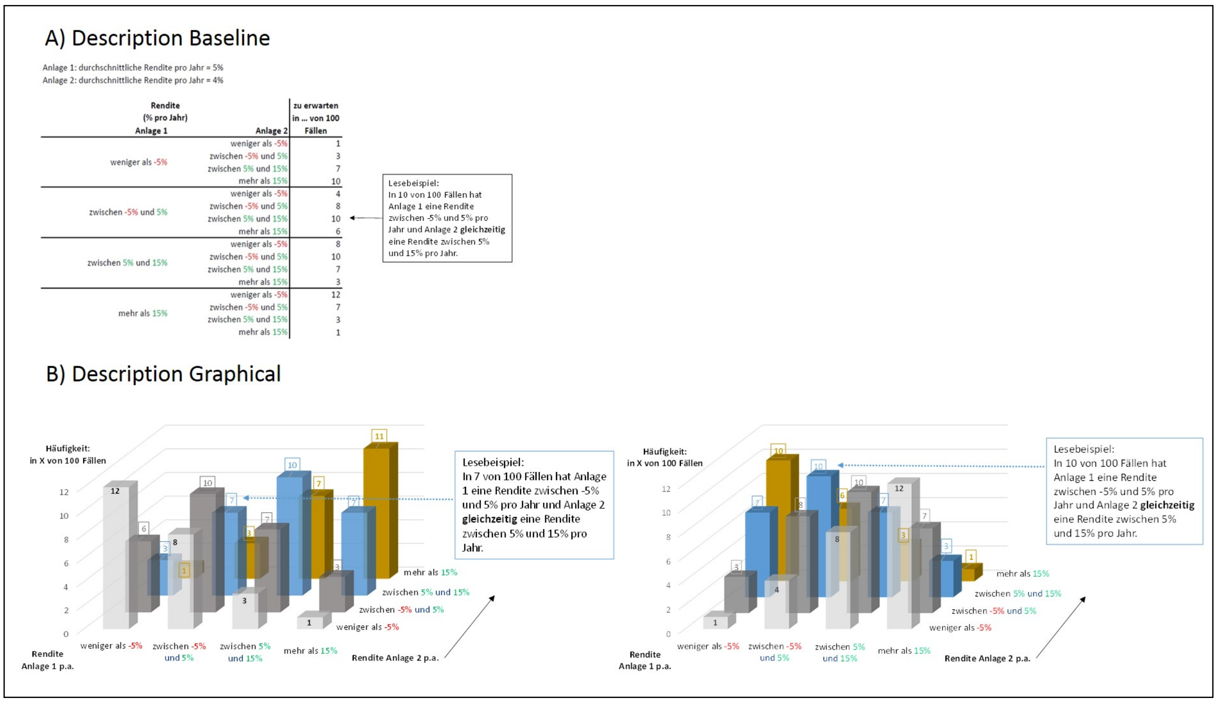


Figure 6: : Changes in presentation formats - Experiment II

These graphs are illustrative examples for the treatments that have changed in comparison to Experiment I. The graph in the first row show the information presented in the baseline description treatment, examplarily for the negative correlation condition. We included a reading example, saying *In 10 out of 100 cases asset 1 has an annual return between -5% and 5%, while asset 2 at the same time has an annual return between 5% and 15%.* The second row depicts information given in the the graphical description treatment for both - the negative and the positive correlation condition. Note that treatments were held constant between participants, but every participant faced both conditions; the order of conditions was counterbalanced. The labels are in German. Translations: 'Anlage X (durchschnittliche Rendite pro Jahr = y%)' means 'Asset X (average return per year = y%)'. 'zu erwarten in ... von 100 Fällen' means 'to be expected in ... of 100 cases'.'Rendite Simulation für Anlage 1 & 2' means 'Return-Simulation for Assets 1 & 2'.



Rendite (% pro Jahr) Anlage 1	Anlage 2	zu erwarten in ... von 100 Fällen
weniger als -5%	weniger als -5%	1
	zwischen -5% und 5%	3
	zwischen 5% und 15%	7
	mehr als 15%	10
zwischen -5% und 5%	weniger als -5%	4
	zwischen -5% und 5%	8
	zwischen 5% und 15%	10
	mehr als 15%	6
zwischen 5% und 15%	weniger als -5%	8
	zwischen -5% und 5%	10
	zwischen 5% und 15%	7
	mehr als 15%	3
mehr als 15%	weniger als -5%	12
	zwischen -5% und 5%	7
	zwischen 5% und 15%	3
	mehr als 15%	1

Figure 7: Realized Correlation and Comovement by Experiment

For each of the experiments, this figure displays the fraction of realized correlations and comovement for all participants in the experience treatments.

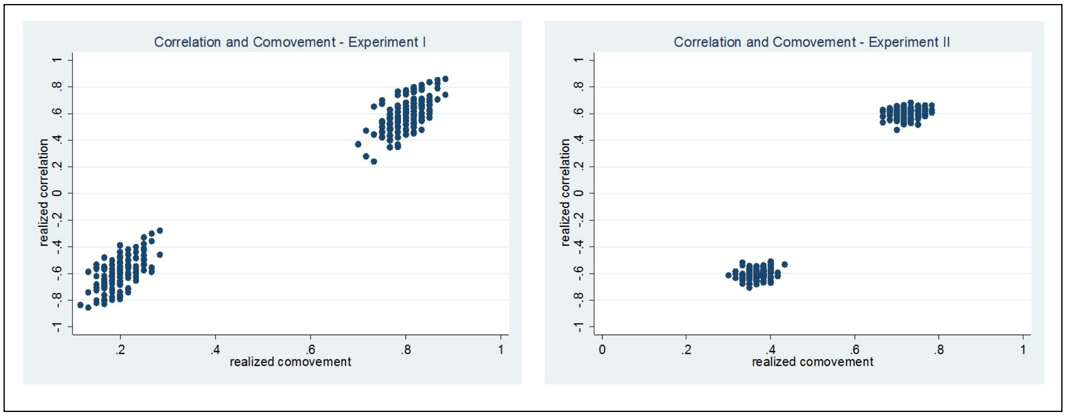


Table 1: Experiment 1 – Treatments: Probability Distributions

Tables show the joint distribution for asset 1 (returns in first row) and asset 2 (returns in first column) for the two different correlation conditions. Marginal distributions are kept constant across treatments and experiments. Means are 5.0% for asset 1 and 4.0% for asset 2. Standard-deviations are 13.0% for both assets. Both conditions are shown to every participant in random order (counterbalanced within-subject design). What varies between participants is the way the return information is presented.

Negative correlation condition: Pearson-Correlation of −0.6

return	−25%	−5%	15%	35%	sum
−26%	1%	0%	0%	4%	5%
−6%	0%	9%	36%	0%	45%
14%	0%	36%	9%	0%	45%
34%	4%	0%	0%	1%	5%
sum	5%	45%	45%	5%	100%

Positive correlation condition: Pearson-Correlation of +0.6

return	−25%	−5%	15%	35%	sum
−26%	4%	0%	0%	1%	5%
−6%	0%	36%	9%	0%	45%
14%	0%	9%	36%	0%	45%
34%	1%	0%	0%	4%	5%
sum	5%	45%	45%	5%	100%

Table 2: Summary Statistics

Numbers in brackets indicate the range of possible values, e.g. values 1-5 for willingness to take financial risks. Financial literacy is measured as the number of correctly answered questions in the test proposed by Fernandes, Lynch, and Netemeyer (2014). Numeracy is measured as the number of correctly answered questions in the test proposed by Cokely, Galesic, Schulz, and Ghazal (2012).

	All		Description		Exp. Numerical		Exp. Graphical	
	Mean	Std. Dev	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Age	22.38	3.01	22.36	3.05	22.57	3.09	22.21	2.91
Fraction Male	0.48	0.50	0.50	0.50	0.46	0.50	0.47	0.50
Owns Equity	0.23	0.42	0.18	0.39	0.25	0.44	0.25	0.44
Interested in Financial Markets	0.65	0.48	0.63	0.48	0.68	0.47	0.64	0.48
Willingness to Take Risks (1-5)	2.63	1.05	2.61	1.05	2.64	1.08	2.64	1.03
Has Taken Statistics Course	0.70	0.46	0.67	0.47	0.67	0.47	0.77	0.42
Financial Literacy (0-12)	6.99	2.56	7.06	2.56	6.95	2.61	6.95	2.53
Numeracy (0-4)	1.29	1.29	1.30	1.33	1.33	1.31	1.23	1.23

Table 3: Allocation into Diversification Asset 2

Panel A shows the average allocation to the diversification asset 2 in % by condition (positive versus negative correlation) and treatment (description versus experience numerical versus experience graphical). Panel B shows the difference in differences between conditions by treatments.

Panel A: Descriptive Statistics on Allocation

	Negative Correlation	Positive Correlation	Difference	t-stat	Average
Description	31.02	33.08	2.06	0.73	32.05
Experience Numerical	36.56	29.19	-7.37	-2.38	32.88
Experience Graphical	42.93	32.31	-10.62	-3.74	37.62

Panel B: Differences between Treatments

	Diff in Diff	t-stat	Diff in Average	t-stat
Experience Numerical - Description	-9.43	-2.56	0.83	0.37
Experience Graphical - Description	-12.68	-3.41	5.56	2.45
Experience Graphical - Experience Numerical	-3.25	-0.83	4.74	2.08

Table 4: Presentation Format and Asset Allocation

$Share_2$ is the investment in asset 2. Specification (2) only includes subjects investing 50% or less in asset 2. Asset 2 has a lower return and the same marginal distribution compared to Asset 1; it should thus only be interesting because of its diversification potential. Specification (3) looks at subjects' first decision only. Experience Numerical is a dummy equal to 1 if a subject was randomly assigned to this treatment. Experience Graphical is a dummy equal to 1 if a subejct was randomly assigned to this treatment. The description treatment is omitted. Positive Correlation is a dummy equal to 1 (0) if the correlation for this decision was 0.6 (-0.6). Learning is an interaction term that is equal to 1 if a subject faces a positive correlation and is in the second round of the experiment (second decision). Second Decision is a dummy equal to 1 if a subject is in the second round of the experiment. We run random effects regressions (except regression (3)) to take account of participant-specific effects. All subjects face two decision, one with a correlations between asset returns of -0.6 and 0.6, respectively. Standard-errors are reported in brackets. 1/2/3 stars denote significance at the 10/5/1%-level.

	(1) $Share_2$ *All*	(2) $Share_2$ *$Share_2$ <=0.5*	(3) $Share_2$ *First Decision*	(4) $Share_2$ *All*
Numerical x Pos. Corr.	-0.09***	-0.08***	-0.09*	-0.09***
	(0.04)	(0.03)	(0.06)	(0.04)
Graphical x Pos. Corr.	-0.13***	-0.08***	-0.14***	-0.13***
	(0.04)	(0.03)	(0.05)	(0.04)
Experience Numerical	0.06*	0.05**	0.04	0.06*
	(0.03)	(0.02)	(0.04)	(0.03)
Experience Graphical	0.12***	0.09***	0.12***	0.12***
	(0.03)	(0.03)	(0.03)	(0.03)
Positive Correlation	0.02	0.01	0.03	0.03
	(0.03)	(0.02)	(0.04)	(0.03)
Learning				-0.02
				(0.04)
Second Decision				0.01
				(0.02)
Constant	0.31***	0.27***	0.31***	0.31***
	(0.02)	(0.02)	(0.03)	(0.02)
Random Effects	YES	YES	NO	YES
No. obs.	572	497	286	572

Table 5: Presentation Format and Asset Allocation

$Share_2$ is the investment in asset 2. Specification (1) and (4) look at the overall sample. Specification (2) Specification (5)only includes participants with a low sampling error, namely who sampled a correlation between -0.55 and -0.65 in the negative and between 0.55 and 0.65 in the positive correlation condition. Last Correlation Pos is a dummy equal to 1 if subjects' last draw depictured a positive correlation. First Correlation Pos is a dummy equal to 1 if subjects' last draw depictured a positive correlation. Last Return Asset 1 and Last Return Asset 2 are the subjects last returns sampled for asset 1 and 2 respectively. First Return Asset 1 and First Return Asset 2 are the subjects first returns sampled for asset 1 and 2 respectively. Experience Numerical is a dummy equal to 1 if a subject was randomly assigned to this treatment. Experience Graphical is a dummy equal to 1 if a subejct was randomly assigned to this treatment. The description treatment is omitted. Positive Correlation is a dummy equal to 1 (0) if the correlation for this decision was 0.6 (-0.6). We run random effects regressions to take account of participant-specific effects. All subjects face two decision, one with a correlations between asset returns of -0.6 and 0.6, respectively. Standard-errors are reported in brackets. 1/2/3 stars denote significance at the 10/5/1%-level.

	(1) $Share_2$ *All*	(2) $Share_2$ *Recency*	(3) $Share_2$ *Primacy*	(4) $Share_2$ *Recency/Primacy Ret*	(5) $Share_2$ *Real. Corr. +/- 5pp*
Last Corr Pos		-0.02			
		(0.03)			
First Corr Pos					
			-0.04*		
			(0.02)		
Last Return Asset 1				0.09	
				(0.08)	
Last Return Asset 2				-0.06	
				(0.08)	
First Return Asset 1				-0.04	
				(0.08)	
First Return Asset 2				0.03	
				(0.08)	
Numerical x Pos. Corr.	-0.09***	-0.08**	-0.07*	-0.09**	-0.13***
	(0.04)	(0.04)	(0.04)	(0.03)	(0.05)
Graphical x Pos. Corr.	-0.13***	-0.12***	-0.10**	-0.13***	-0.11**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)
Experience Numerical	0.06*	0.06**	0.07**	0.05*	0.08**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)
Experience Graphical	0.12***	0.12***	0.13***	0.13***	0.13***
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)
Positive Correlation	0.02	0.02	0.02	0.02	0.02
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Constant	0.31***	0.31***	0.31***	0.31***	0.31***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Random Effects	YES	YES	YES	YES	YES
No. obs.	572	572	572	572	371

Table 6: Attention - Time spent with the Information about Asset Returns

Panel A shows the average total time spent with the information (pictures) about asset returns by treatment. This information is shown by condition (positive versus negative correlation) as well as decision round. Panel B shows the allocation to the diversification Asset 2 for participants who spent above (below) median time to view the information about the asset returns. Median splits were conducted for each treatment separately.

Panel A: Time in Seconds by Presentation Format				
	Neg. Correlation	Positive Correlation	Difference	t-stat
Time by Condition				
Description	75.28	74.54	-0.73	-0.08
Experience Numerical	111.04	108.40	-2.64	-0.30
Experience Graphical	109.22	102.51	-6.71	-0.71
	First Round	Second Round	Difference	t-stat
Time by Decision Round				
Description	67.85	81.97	14.13	1.68
Experience Numerical	123.73	95.71	-28.01	-3.32
Experience Graphical	122.27	89.47	-32.80	-3.60

Panel B: Attention Time and Asset Allocation				
	Negative Correlation	Positive Correlation	Difference	t-stat
Total Time < Median				
Description	30.31	34.02	3.71	0.92
Experience Numerical	37.15	28.16	-8.99	-2.03
Experience Graphical	42.73	30.56	-12.16	-2.96
Total Time > Median				
Description	31.79	32.10	0.41	0.10
Experience Numerical	36.00	30.26	-5.74	-1.31
Experience Graphical	43.11	34.21	-8.90	-2.26

Table 7: Presentation Format and Correlation Perception

The panels show the frequency of each answer-category for questions on beliefs about dependence. Boxes around numbers indicate correct answers (panel A1 does not have one correct answer). All answers are shown by Treatment (Description, Experience Numerical, Experience Graphical) and condition (Positive Correlation, Negative Correlation). Below Panels A1-2, you will find the mean category for each treatment and condition and differences between these means by treatment. Below panel B you will find differences in means between conditions (positive and negative correlations) for each treatment as well as differences in conditional differences between treatments. Panel C resports the average sum of the normalized score A1+A2+B. Each of the scores was normalized for each participant byvsubtracting the sample mean from his answer and dividing it by the sample standard deviation. Standard errors are in brackets. 1/2/3 stars denote significance at the 10/5/1%-level.

	Description		Experience Numerical		Experience Graphical	
	Neg Corr	Pos Corr	Neg Corr	Pos Corr	Neg Corr	Pos Corr
Panel A1 (Overall Dependence): Asset 1 and 2 move...						
in opposite directions 1	2	1	4	2	5	1
2	36	25	48	3	57	9
3	44	51	37	23	23	25
4	16	19	7	62	6	56
together 5	0	2	0	6	1	1
mean	2.75	2.95	2.49	3.69	2.36	3.51
- negative correlation	-	0.20	-	1.21^{***}	-	1.15^{***}
		(0.11)		(0.10)		(0.11)
chi^2-test of differences						
-Diff in Corr in Description		-	-	1.01^{***}	-	0.95^{***}
-Diff in Corr in Experience Numerical	-	-	-	-		-0.06
Panel A2 (Upside Dependence): Given that asset 1's price increases, I expect asset 2 to...						
decrease 1	32	17	45	2	58	10
2	55	65	43	37	27	33
increase 3	57	11	57	8	7	49
mean	1.79	1.99	1.61	2.57	1.45	2.42
-negative correlation	-	0.20^{**}	-	0.96^{***}	-	0.98^{***}
		(0.09)		(0.09)		(0.10)
chi^2-test of differences						
-Diff in Corr in Description	-	-	-	0.76^{***}	-	0.78^{***}
-Diff in Corr in Experience Numerical	-	-	-	-	-	0.02

	Description		Experience Numerical		Experience Graphical	
	Neg Corr	Pos Corr	Neg Corr	Pos Corr	Neg Corr	Pos Corr
Panel B (Frequency of Co-Movement): Given that asset 1's price increases, I expect asset 2 to increase in ... out of 100 cases. (Any answer from 0 to 100 was allowed.)						
[0,20)	25	25	18	7	17	6
20	6	3	8	4	13	5
(20,40)	17	16	13	6	16	5
40	11	7	15	1	11	6
(40,60)	27	28	22	20	12	14
60	7	6	6	3	7	7
(60,80)	3	5	5	17	6	7
80	1	2	5	12	7	15
(80,100]	1	6	4	26	3	27
mean	34.33	38.27	40.65	63.07	39.22	62.89
- negative correlation	-	3.94	-	22.42***	-	23.67***
		(3.29)		(3.54)		(3.58)
chi^2-test of differences						
-Diff in Corr in Description	-	-	-	18.48***	-	19.73***
-Diff in Corr in Experience Numerical	-	-	-	-	-	1.25
Panel C Overall Dependence Score						
mean	-0.38	-0.41	-0.20	0.70	-0.24	0.54
- negative correlation	-	-0.03	-	0.90***	-	0.78***
		(0.17)		(0.17)		(0.19)
chi^2-test of differences						
-Diff in Corr in Description		-	-	0.93***	-	0.81***
-Diff in Corr in Experience Numerical	-	-	-	-		-0.12

Table 8: Estimation of the Loss Probability by Presentation Format

The table shows subjects' average estimates of the loss probability of their portfolio, which was the answer to the question *in how many cases their final wealth will fall below the invested amount*, as well as the true value.

Estimation of expected "loss cases" and true values				
	Negative Correlation	Positive Correlation	Difference	t-stat
Average Estimate				
Description	32.77	33.23	-0.47	-0.18
Experience Numerical	32.46	27.49	4.97	1.95
Experience Graphical	27.84	28.33	-0.49	-0.21
Average True Value				
Description	27.34	44.60		
Experience Numerical	24.04	45.48		
Experience Graphical	20.26	44.51		

Table 9: Summary Statistics

This table reports summary statistics (means and standard deviations) for participants in Experiment II by treatment. Numbers in brackets indicate the range of possible values, e.g. values 1-5 for willingness to take financial risks. Financial literacy is measured as the number of correctly answered questions in the test proposed by Fernandes, Lynch, and Netemeyer (2014). Numeracy is measured as the number of correctly answered questions in the test proposed by Cokely, Galesic, Schulz, and Ghazal (2012).

	Des.		Des. Graph		Exp. Num.		Exp. Graph.	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Age	23.33	6.78	22.69	4.47	21.48	2.84	22.89	4.80
Fraction Male	0.51	0.50	0.39	0.49	0.56	0.50	0.43	0.50
Owns Equity	0.20	0.41	0.13	0.34	0.37	0.49	0.20	0.40
Interested in Financial Markets	0.64	0.48	0.52	0.50	0.67	0.47	0.60	0.49
Willingness to Take Risks (1-5)	2.89	1.17	2.62	1.13	2.90	1.09	2.79	1.06
Has Taken Statistics Course	0.62	0.49	0.59	0.50	0.61	0.49	0.59	0.50
Financial Literacy (0-12)	7.11	2.25	6.29	2.33	7.26	2.07	6.77	2.54
Numeracy (0-4)	1.16	1.29	1.04	1.20	1.31	1.31	1.11	1.31

Table 10: Allocation into Diversification Asset 2 - Experiment II

Panel A shows the average allocation to the diversification asset 2 in % by condition (positive versus negative correlation) and treatment (description versus description graphical versus experience numerical versus experience graphical). Panel B shows the difference in differences between conditions by treatments.

Panel A: Descriptive Statistics on Allocation

	Negative Correlation	Positive Correlation	Difference	t-stat	Average
Description	44.86	43.24	-1.62	-0.52	44.05
Description Graphical	50.39	57.76	7.38	2.32	54.07
Experience Numerical	38.45	37.80	-0.64	-0.21	38.13
Experience Graphical	45.05	36.90	-8.15	-2.88	40.97

Panel B: Differences between Treatments

	Diff in Diff	t-stat	Diff in Average	t-stat
Description Graphical - Description	7.9	2.15	10.02	4.48
Experience Numerical - Description	0.98	0.26	-5.92	-2.73
Experience Numerical - Description Graphical	-8.02	-2.12	15.94	7.25
Experience Graphical - Description	-6.52	-1.66	-3.08	-1.44
Experience Graphical - Descripton Graphical	-15.53	-3.97	-13.10	-6.04
Experience Graphical - Experience Numerical	-7.51	-2.19	2.84	1.37

Table 11: Presentation Format and Correlation Perception - Experiment II

The panels show the accuracy of questions on beliefs about dependence.). All answers are shown by Treatment (Description, Description Graphical, Experience Numerical, Experience Graphical) and condition (Positive Correlation, Negative Correlation).

	Des.		Des. Graph.		Exp. Num.		Exp. Graph.	
	Neg Corr	Pos Corr	Neg Corr	Pos Corr	Neg Corr	Pos Corr	Neg Corr	Pos Corr
Panel A1 (Overall Dependence): Asset 1 and 2 move... I expect asset 2 to...								
in opposite directions 1	6	2	16	3	2	1	3	1
2	60	17	38	26	60	10	46	9
3	19	18	18	22	22	28	34	29
4	15	51	14	30	8	55	8	52
together 5	2	12	0	8	1	1	0	1
mean	2.48	3.54	2.35	3.16	2.42	3.47	2.52	3.47
- negative correlation		1.06***		0.81***		1.05***		0.95***
		(0.13)		(0.15)		(0.11)		(0.11)
don't know	7.27	9.09	13.13	10.10	6.06	4.04	3.19	2.13
Panel A2 (Upside Dependence): Given that asset 1's price increases, I expect asset 2 to...								
decrease 1	65.4	22.8	71.8	45.4	79.0	20.0	75.3	23.08
2	19.8	17.8	12.9	11.6	11.1	15.0	9.9	18.0
increase 3	14.9	59.4	15.3	43.02	9.9	65.0	15.6	59.0
mean	1.50	2.37	1.44	1.97	1.31	2.45	1.40	2.36
- negative correlation		0.87***		0.54***		1.14***		0.96***
		(0.11)		(0.13)		(0.13)		(0.13)
chi^2-test of differences								
-Diff in Corr in Description				-.3**		0.3*		0.1
-Diff in Corr in Description Graphical						0.6***		0.4**
- Diff in Corr in Experience Numerical								-0.2
don't know	8.2	8.2	14.1	13.1	18.2	19.2	17.2	16.0
Panel B (Frequency of Co-Movement): Given that asset 1's price increases, I expect asset 2 to increase in ... out of 100 cases.								
[0,20)	67	39	60	47	19	10	10	9
[19,41)	19	22	14	18	37	20	48	19
[40,56]	10	15	13	13	21	23	15	14
(55,71)	6	10	4	3	13	24	13	27
(70,85)	4	9	3	7	7	7	4	14
(84,100]	4	15	5	11	2	15	3	10
mean	22.95	40.27	24.75	33.36	38.83	53.73	39.14	54.46
- negative correlation		17.33***		8.61**		14.89***		15.32***
		(3.78)		(4.17)		(3.38)		(3.46)

A Appendix: Overview of Variables

The following table briefly defines the main variables collected in our experiments.

Panel A: Outcome Variables	
Variable Name	Description
Frequency of Co-movement	'Given that asset 1's price increases, I expect asset 2's price to increase in ... out of 100 cases.' (Any numerical answer from 0 to 100 was allowed.)
Loss Probability - Estimate	'In how many cases their final wealth will fall below the invested amount?' (Any numerical answer from 0 to 100 was allowed.)
Loss Probability - True Value	Number of cases out of 100, in which the final wealth will fall below the invested amount based on the participant's chosen allocation.
Overall Dependence	'Asset 1 and 2 move ...' (Three radiobuttons from 'in opposite directions' to 'together'.)
$Share_2$	The share invested in asset 2 out of an endowment of 10'000 €
Upside Dependence	'Given that asset 1's price increases, I expect asset 2 to...' (Three radiobuttons from 'decrease' to 'increase'.)
Overall Dependence Score	Each of the three dependence scores is normailzed (participants' estimate minus the sample mean divided by the sample standard deviation). The overall score is calculated by adding up the three normalized scores.
Confidence	'How confident are you about your investment decision?' (Seven radiobuttons from 'not confident at all' to 'very confident'.)

Panel B: Control Variables	
Variable Name	Description
Age	Age of the participant.
Experience Numerical	Dummy equal to 1 if a subject was randomly assigned to this treatment.
Experience Graphical	Dummy equal to 1 if a subject was randomly assigned to this treatment.
Financial Literacy	Financial Literacy Score between 0 and 12: The number of correct answers to twelve financial literacy questions from Fernandes, Lynch, and Netemeyer (2014). Item (8) from the original test was left out since the experiments were conducted in Germany (it is a question related to 401(k) plans and therefore specific to the US setting).
Financial Market Interest	'Are you generally intersted in stock or financial markets?' (Answer: Yes or no.)
Gender	Gender of the participant.
Learning	Interaction term that is equal to 1 if a subject faces a positive correlation and is in the second round of the experiment (second decision)
Numeracy	Numeracy Score betwen 0 and 4: The number of correct answers to the traditional format version of the Berlin Numeracy Test from Cokely, Galesic, Schulz, and Ghazal (2012).
Numerical x Pos. Corr.	Interaction term equal to 1 if a subjects is in the experience numerical treatment and faces the positive correlation condition.
Positive Correlation	Dummy equal to 1 if a subject faces the positive correlation condition (correlation of +0.8)
Risk Attitude	Self-reported: 'Please estimate your willingness to take financial risk.' (Five radiobuttons from 'not willing to accept any risk' to 'willing to accept substantial risk to potentially earn a greater return'.)
Second Decision	dummy equal to 1 if a subject is in the second round of the experiment.
Statistics Course	'Have you attended a university statistics course?' (Answer: Yes or no.)
Statistics Knowledge	'How would you describe your knowledge about statistics?' (Four radiobuttons from 'good' to 'bad'.)
Stock-Ownership	'Do you own stocks or an equity mutual fund?' (Answer: Yes or no.)
Time	The total time spent with the information (pictures) about asset returns in seconds