How much risk can I handle?
The role of experience sampling and graphical displays on one's investment risk appetite and comprehension

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Abstract

Financial professionals have a great deal of discretion concerning how to relay information about the risk of financial products to their clients. This paper examines how different risk presentation modes influence how well investors understand the risk-return profile of financial products and how much risk they are willing to accept. We analyze four different ways of communicating risk: (i) numerical descriptions, (ii) experience sampling, (iii) graphical displays, and (iv) a combination of these formats in a 'risk tool simulation'. Participants receive information about a risky and a risk free fund and make an allocation in an experimental investment portfolio. We find that risky allocations are elevated in both the risk tool simulation and experience sampling conditions. Greater risky allocations are mediated by decreased risk perception, increased confidence in the risky fund, and a lower estimation of the probability of a loss. Despite these indicators of optimism about the risky fund, participants in the risk tool simulation underestimate the probability of a high gain and are more accurate on comprehension questions on the expected return and the probability of a loss. We find no evidence of greater dissatisfaction with returns in these conditions and observe a willingness to take on similar levels of risk in subsequent allocations. Our paper has important implications for the current debate about regulating the communications between financial advisors and their clients.

Keywords: Risk Taking, Risk Attitude, Risk Perception, Presentation Mode, Risk Comprehension, Experience-Description Gap

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1. INTRODCUTION

One of the most important financial decisions is how much risk to bear in one's investment portfolio. For example, with a $100,000 retirement portfolio investing $50,000 instead of $40,000 to an equity fund as opposed to a money market results in an expected return of $100,000 more over a 30 year time horizon.[1] Though taking on more risk is certainly not a panacea for everyone's retirement portfolio, the ability to accurately assess both the upside potential and downside risk involved in such a decision would undoubtedly help people to make more informed financial decisions that better suit their preferences.

The manner in which people acquire knowledge about risk of investment products may affect how well they comprehend risk and have a dramatic influence on this crucial decision. The decision making literature distinguishes between two fundamentally distinct ways in which people learn about risk: *description* vs. *experience.* Decisions from *description* are based on explicitly stated probabilities associated with outcomes. Decisions from *experience* are based on sampling possible outcomes, meaning that the underlying probabilities must be judged or inferred based on the observed evidence. In an investment context, risk can be *described* in summary form, e.g., historical returns or factsheets. Alternatively, knowledge about risk can be acquired through *experience,* through feedback about the outcomes of previous decisions or observing outcomes in the market.

The literature on the 'experience-description gap' documents situations in which these two decision modes lead to different decisions. These findings raise the issue of what is the best way to present information about the riskiness of investment products. As empirical researchers, it may seem intuitive to us that risk should be described in summary statistical form. However, this is not obvious from this literature. Decision-making from experience can reduce or reverse decision-making biases, such as overweighting of rare event in prospect theory (Baron & Erev 2003).

We contribute to the existing literature by extending the literature on the experience-description gap to in the domain of investment decision making. This is a more complex decision making task than what has been examined so far in the literature since outcomes are continuous. The question of how risk presentation format influences investing is important since financial professionals have a great deal of discretion concerning how to relay this information to their clients. At worst they do not assess risk preferences at all or ask irrelevant questions about risk-seeing in other domains, such as "Are you a bungee jumper?" At best they ask clients how willing they are to take financial risks on a 1-5 scale.

[1] For the return on the MSCI US, we calculated the average return based on the historical returns from 1973 to 2008 of 8.95%. For the risk free return, we assumed an interest rate of 3.35%.

Our research question has important implications for policy making. In the EU, advisors are legally obliged to assess customers' risk preferences and issue '*appropriate guidance on and warnings of the risks associated with investments'* during the advisory process.[2] Similarly, the Securities and Exchange Commission in the US instructs banks to inform their clients about past performance of investment products and their special risks. Nevertheless, there is little instruction about how risk information should be presented. Research is needed to elucidate the implications of risk presentation format on risk taking and comprehension.

With this end in mind, we developed a 'risk tool simulation' to more completely inform investors about the risk of investment products.[3] The risk tool is a simulation that incorporates both experience sampling based on the historical distribution of the MSCI and a graphical display of the full historical distribution. The simulation forces participants to sample several possible outcomes for a five-year investment in a stock fund – the "risky fund". Each sampled outcome is used to build up the distribution and then the entire distribution is shown. Participants are also shown the expected five-year return of a risk free fund. Finally, participants make an allocation between the risky fund and the risk free fund. We contrast this simulation with a numerical *description* of the expected value and variance of the return of the risky fund. Further, we also break-down the simulation into its constituent parts with a pure experience sampling and a pure distribution condition. These different risk presentation modes are tested in an incentive compatible experimental investment portfolio, conducted online with participants drawn from a German university and the general population in the United States.

We find that the risk tool simulation increases the propensity to take financial risks. This effect appears to be driven more by experience sampling than the displays of historical distributions. Thus, a main contribution of this paper is an extension of the literature on the experience-description gap to show that experience sampling leads to greater risk taking in the context of investing, in which outcomes are continuously distributed. We document three psychological mechanisms that underlie this effect: reduced overweighting of rare events, lower risk perception, and higher confidence about investing in the risky fund.

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[2] See Article 19 of the Markets in Financial Instruments Directive (MiFID) of the European Union (The European Parliament and the European Council, 2004).

[3] Goldstein, Johnson, and Sharpe (2006) introduce a similar tool the so called "distribution builder". This tool elicits clients' preferences without requiring them to engage in complicated computations by using a graphical displays, frequency information, and experience sample. The aim is to elicit preferences, such as the coefficient of relative risk aversion and the loss aversion parameter for a sample of adults saving for retirement.

A second major contribution of this paper is improving risk communication to give investors a greater appreciation for potential benefits and the risks of investment products. We asses participant's comprehension of the risk-return profile of the risky investment product by asking them questions about the expected return and the probabilities associated with different outcomes. The risk tool simulation enhances comprehension of the stock fund along two dimensions: the expected return and the perceived probability of a loss.

Another potential benefit of the risk tool simulation is that it leads participants to be less reactive when they receive a return that falls below expectations. Instead of accepting lower risk in a subsequent allocation decision, akin to pulling out of the market after a downturn, participants in the risk tool condition are more likely to "stay the course" and make a consistent subsequent allocation decision.

The remainder of this paper proceeds as follows: in Section 2 we provide a literature review and formulate our hypotheses. Section 3 describes our experimental paradigm. Our main results are presented in Section 4. We describe how four different types of presentation formats influence people's investment allocation decisions: i) numerical description, ii) experience sampling, iii) graphical displays of distributions, and iv) a combination of these with the risk tool simulation. Section 5 explores comprehension and underlying psychological factors that affect the allocation decision. Section 6 examines whether the increased risk taking with the risk simulation tool leads to decision regret by analyzing satisfaction with returns and a subsequent allocation decision. Section 7 examines the robustness of the experience-description gap that we observe for investment decisions and shows that it cannot be accounted for by sampling error or recency effects. Section 8 provides a discussion of our conclusions.

2. LITERATURE REVIEW AND HYPOTHESIS

Research on risk presentation format addresses the question of whether risk taking behavior varies depending on whether the risk is experienced instead of simply described. Experiencing the risk means that the probabilities associated with outcomes are not known or explicitly stated. Rather, they have to be learned either through feedback from previous decisions or through experience-sampling, i.e. allowing people to sample possible outcomes before making a choice. This mirrors many decisions in everyday life, for which people often do not have access to exact statistical probabilities and have to estimate risk based on personal experience and external information. For example, people draw on their own and other's past experiences when deciding whether to back up their hard drive, purchase insurance, or how cautiously to drive. Most are not aware of the probability of whether the S&P 500 will go up or down

over the next year. Rather, their intuition about this derives from their appreciation of the volatility they have experienced in the past.

Given identical underlying probability distributions, decisions based on description and experience can be substantially different, particularly for decisions that involve rare events. Hertwig, Barron, Weber and Erev (2004) demonstrate that decisions based on numerical descriptions, which explicitly give information about outcomes and probabilities, differ significantly from decisions based on experience, in which probabilities are learned through pushing buttons to sample possible outcomes. In contrast to the overweighting of small probabilities that occurs with numerical descriptions, described by the probability weighting function of prospect theory (Kahneman and Tversky 1979), their results suggest that people *under*weight small probabilities if they experience the risk through sampling. For example, in the descriptive condition of Hertwig et al. (2004), 36% choose to gamble on a .8 chance to win 4 points (.2 chance of 0 points) over a sure gain of 3 points, while in the experience condition 88% chose to gamble.

This effect has been observed in many studies, despite little consensus about the underlying mechanisms behind it (e.g., Barron & Erev 2003, Weber, Shafir, & Blais 2004, Hau, Pleskac, Kiefer and Hertwig 2008, see Rakow and Newell 2008 for review). In description based decisions, rare events are overweighted, which induces risk seeking in the domain of gains (e.g., preference for a 10% chance of winning $10 over a sure gain of $1) and risk aversion in the domain of losses (preference for a sure loss of $1 over a 10% of losing $10), consistent with prospect theory. In experienced based decisions, the rare events are not overweighted, leading to risk aversion for gains and risk seeking for losses. Several studies on experience-description gap claim that it can be explained by sampling error (rare events are not observed due to a small number of draws ending up in a discrepancy between objective and experienced probability) and recency effects (overweighting of recently sampled information). We will address these questions in our in Section 7.

Though the literature is clear on the point that experience sampling leads to greater risk taking among experimental lotteries that have a small probability of a loss, it has not been tested whether this phenomena also occurs in more contextualized domains. The decision to invest in an equity fund over a multi-year time horizon fits the risk profile of a small probability of a loss. For example, over a five-year time horizon, the probability of a loss is < 20%.[4] Thus, in this context experience sampling is expected to increase risky allocations.

[4] Based on the historical returns of the MSCI USA (1973-2008) the probability of getting less than your invested capital is 16%.

In addition to experience sampling, the risk tool simulation we test displays return distributions. Previous research in the myopic loss aversion literature suggests that this may also increase risk taking. Benarzti and Thaler (1999) offer participants 100 repeated plays of a gamble with a positive expected value and later show them distribution of returns graphically. Many who initially decline the gamble subsequently accept it after seeing the return distribution. The authors hypothesize that the reversal in preference is due to the tendency to overestimate the probability of a loss until viewing the return distribution. They recommend that investors should be presented with aggregated distributions that reflect the range of possible outcomes of their investment decisions because people seem unable to comprehend the characteristics of this distribution from descriptions of probabilities. Using a different graphical presentation format**,** Beshears, Choi, Laibson and Mandrian (2010) also found that distributions can increase risk taking. The graphs they used showed the historical percentage returns of equity funds over a 30 year time horizon, ordered by lowest return to highest return. These displays increased allocation to equities by 11- 12%.

Based on the research summarized above, we hypothesized in Experiment I that riskier allocations would be made in the risk simulation tool, which incorporates both experience sampling and distributions of returns, compared to a description condition. We confirm this hypothesis and replicate this finding in Experiment II, which also included a pure experience sampling and a pure distribution condition in order to elucidate which presentation mode increases allocations to a greater degree.

The literature proposes that the experience-description gap for prospects with a small probability of a loss operates through reduced overweighting of this probability (Baron and Erev 2003). Researchers in the investment decision making area have also stressed the important role of the perceived probability (Benarzti & Thaler 1999, Klos, Weber, and Weber 2005). However, as far as we know, the estimated probability of a loss has never been explicitly assessed. In Experiment III, we assessed the probability of a loss and hypothesized that it would mediate increased risk seeking with experience sampling.

Experiment III also looks for other drivers of increased risk seeking that may change depending on the decision-making context. Classical portfolio theory (e.g., Markowitz 1952) characterizes the decision about how much risk to accept in one's investment portfolio as a trade-off between an investment's expected return and variance, determined by the individuals' risk attitudes:

$$\textit{Risk Taking} = \textit{(Expected Return)-(Risk Attitude)(Expected Variance)}$$

However, more recent behavioral studies imply that individual's risk taking behavior can be better explained by *subjective* measures such as risk perception and perceived return (see Sarin and Weber 1993, Jia et al. 1999 and Nosić and Weber 2010):

$$\textit{Risk Taking} = \textit{(Perceived Return)} - \textit{(Risk Attitude)(Perceived Risk)}$$

These subjective beliefs can vary depending on the domain and situational features of the decision making environment. For example, risk attitude and risk perception elicited in a lottery context are not related to portfolio choices (Nosic and Weber 2010). Even within the same context, risk perception may vary. The perceived risk of an investment option changes depending on whether it follows from a series of gains or losses (Weber and Milliman 1997). This evidence suggests that these subjective variables will be influenced by the manner in which risk is communicated.

These subjective measures can show excellent predictive validity, particularly perceived risk. Perceived risk predicts risky choice, despite its weak relationship to the more objective measures, such as standard deviation (Keller, Sarin, and Weber 1986; Klos, Weber, and Weber 2005). Assessing perceived risk results in greater cross-situational stability of risk preferences (Weber and Milliman 1997, Weber, Blais and Betz 2002). Perceived risk has been found to mediate the relationship between situational factors (specifically, gain/loss framing) and risk taking (Sitkin and Pablo 1992, Sitkin and Weingert 1995). In Experiment III, we predict that the relationship between experience sampling and increased risk taking will be mediated by perceived risk and perceived return.

In Experiment III, we assess two other psychological constructs that might help elucidate the relationship between risk communication and risk taking: confidence in the risky fund and feeling informed. Though there is a vast literature on *over*confidence and investment behavior (e.g., Glaser and Weber, 2007), little research has examined the role of subjective feelings of confidence. In research outside of the investing domain, richer information is associated with increased confidence, although it does not increase decision accuracy (Oskamp 1965).

It is often argued that investors do not understand the risk of financial products and therefore show higher risk aversion. The results of Benarzti and Thaler (1999) and Beshears et al. (2010) suggest that comprehension may be increased by displaying historical return distributions. Lejarraga (2010) demonstrated that comprehension may also be increased through experience sampling. In the description condition, participants viewed the probability of rain in four cities. In the experience condition, participants were allowed to sample whether there was sun or rain on a given day in each of the four cities for as long as they wanted. Following a delay period in which participants completed a cognitive task, they estimated the number of days it would rain in a ten-day period in each of the cities. Frequency estimates were more accurate in the experience than in the description condition. Thus, since both experience sampling and distribution displays can be expected to increase comprehension, we hypothesized that people in the risk tool condition will give more accurate estimates of expected returns and probabilities associated with outcomes. This is tested in Experiment III.

Three experiments were conducted to test these hypotheses. In addition to the measures described above, in each experiment we look for evidence of decision regret and reactivity to returns by assessing satisfaction and by asking participants to make an addition allocation decision after receiving their return.

3. EXPERIMENTAL DESIGN AND DATA

Experimental Task

In each of the three experiments, participants were asked to allocate an endowment between two different funds. Fund A was a risk-free fund and fund B was a risky fund, whose payoff was based on the historical returns off the MSCI USA, (which was not known to participants). Participants were informed that at the end of the experiment a "financial market simulation" would be run to determine the five year return on their allocation decision. It was explained that this simulation randomly generated a return based on the underlying distribution of allocation decision that they chose. Participants had the chance to win Amazon.com gift cards for their simulated return.

Participants were randomly assigned to condition in a between-subjects design. Though the conditions differed in the how information about the risk-return profile was presented, all other features of the decision context were held constant. All conditions first provided information about the five year risk-return-profile of the risk-free fund and the risky fund separately (described further below). It was clear that the risk-free fund had a guaranteed return. Participants selected an initial portfolio allocation and then received information about the risk-return profile of the diversified portfolio based on their initial chosen allocation over a five year time horizon. Finally, they could change their initial allocation via a scroll bar and observe how the risk-return profile of the portfolio as a whole changed before making their final allocation.

Experiment III only then assessed psychological measures regarding the risky fund: perceived risk, confidence, and how informed they felt about it. Next, Experiment III assessed comprehension questions about the risky fund: expected return, probability of a loss of investment capital, and probability of a return of 50% or greater. For further information about the differences between experiments see Appendix A. Appendix B gives an overview of the variables and measures they reflect.

In all experiments, before the financial market simulation, participants reported control variables: risk attitude, financial literacy (adapted from van Rooij, Lusardi & Alessi 2007), stock ownership, and demographics. The financial market simulation was run and participants then reported their satisfaction with their outcome on a 7-point scale. Finally, they reported how they would hypothetically allocate their money between the risk free and the risky fund if they could make the same investment decision again.

Stimuli

In all three experiments we tested two conditions – a description condition versus the risk tool condition. The risk tool was developed to use experience sampling and graphical displays to communicate the asset risk in contrast to the way it is usually done in banks – by presenting return expectations with stated information about historical returns. In the risk tool condition they saw the expected returns and potential outcomes of their investment on a graphical interface. They were first shown what the return would be if they were to invest the total amount in the risk free Fund A on a graphical display with a single line. The next step illustrated the expected return and variance of investing the total amount in the risky Fund B. To simulate experience sampling, the program drew potential returns out of the distribution at random and each draw contributed to a distribution function on the screen (see Figure 1a). Participants were allowed to sample for as long as they wanted but were required to sample at least eight draws. After sampling, the simulation rapidly displayed another eight draws and then rapidly built up the entire distribution. After watching the simulation for the risky fund, participants entered an initial asset allocation between Fund A and Fund B and went through the simulation again, which now reflected the underlying distribution of their chosen diversified portfolio. They were able to adjust this allocation and repeat the simulation until they decided on a final allocation.

In the description condition participants were given the expected return as a percentage and the standard deviation for each of the funds. The variance of the risky fund was also explained in terms of frequencies (see Appendix C). They entered an initial asset allocation, saw the effects on return and standard deviation of the diversified portfolio numerically. Next, they could adjust the allocation and see the corresponding effects on the return and standard deviation until they decided on a final decision.

Experiments II and III attempted to deconstruct the risk tool condition by examining two additional conditions: a pure experience sampling condition and a pure distribution condition. In the experience condition participant first drew returns from the distribution of the two funds separately, similar to the sampling procedure in Hertwig, Barron, Weber, Erev (2004). They saw one outcome after the other without building up a distribution function (in contrast to the risk simulation condition) and entered in their initial allocation. Next they drew from the distribution of their chosen fund mix and were able to adjust their allocation and draw again until they decided on a final allocation (see Figure 1b).

In the distribution condition participants viewed the return of the risk free fund on a graphical display (as a single line) and the distribution graph of returns for the risky Fund B and made their initial allocation. Next they could change this allocation and see how the distribution graph changed before deciding on their final allocation (see Figure 1c).

Insert Figure 1 here

Data and Participants

Experiment I was run at the University of Mannheim with one hundred and thirty-three undergraduates[5] (eighty-two male). The mean age was 22.24 with a range from 18 to 50 years. Approximately thirty percent of the students reported owning stocks (stock funds included). It took participants on average nineteen minutes to complete the experiment online, for which they were compensated with the chance to earn money in an incentive-compatible manner, based on the outcome of the financial market simulation of their allocation decision. Participants allocated EUR1,000 and we randomly selected 10 students to receive an Amazon gift card for the amount of the financial market simulation divided by 100 (which resulted in payments between EUR10 and EUR18).

For Experiment II, we recruited one hundred and eighty-eight participants[6] (sixty-six male) from the general population using the subject pool of the Yale School of Management. The mean age was 34 with a range from 18 to 70 years. Participants were overwhelmingly Caucasian with an average income of $47,000 (range from $0 to $199,000). Fifty percent were college educated and approximately forty-five percent owned stocks. Participants again completed the experiment online and were offered a $5 Amazon.com gift certificate for their participation plus a 1 in 20 chance to earn additional performance-based pay based on the outcome their financial market simulation. Participants allocated $100 and earnings ranged from $96 to $144.

In Experiment III, we assessed comprehension and potential mediators. The sample size was increased to three hundred sixty-two participants[7] (one hundred twenty-two male) again using the subject distribution list of the Yale School of Management.[8] Demographics were similar to the ones in Experiment II. The mean age was 35 with a range from 18 to 75 years. Participants were overwhelmingly Caucasian with an average income of $48,000 (range from $0 to $145,000). Fifty-three percent were

[5] Ten participants were dropped from the original sample of 188 because they participated more than once. Five participants were excluded because they failed an attention check question about what the experiment is about, nine because they endorsed just clicking through the experiment or being very distracted, and thirty-one because they did not finish the experiment.

[6] Thirty-seven observations were dropped from the original sample of 237 because the subjects participated in the experiment more than once. Four participants were excluded because they failed to correctly respond to a question about the experimental content, one because he told us not to count his data, and seven because they did not finish the experiment.

[7] Thirty-tree observations were dropped from the original sample of 429 because the subjects participated for the second time. Nine participants were excluded because they failed to correctly respond to a question about the experimental content, fourteen because they told us not to count their data and eleven because they did not finish the experiment.

[8] People were unable to participate if they had already participated in Experiment II.

college educated and approximately forty percent owned stocks. Participants again completed the experiment online in exchange for a 50% chance to earn a $5 Amazon.com gift certificate and a one in 40 chance to earn additional performance-based money based on the outcome of their allocation decision.

4. INFORMATION PRESENTATION AND ALLOCATION DECISIONS

Patterns of Asset Allocation

Participants first received information about the risk free and the risky fund separately. Next they made an initial allocation, which allowed them to view the diversified risk-return profile of this initial allocation. They could adjust their allocation and view the diversified as many times as they wanted before deciding on their final allocation. Only the final allocation was assessed in an incentive compatible manner. Table 1 shows the means of the initial and final allocation to the risky fund.

Insert Table 1 here

We find that the manner in which people acquire knowledge about risk does affect the allocation decision. The final allocation was significantly higher in the risk tool condition in all three experiments. The increased risky allocations in the risk tool condition remains significant when we include control variables using OLS regression analysis[9] in Table 2. Consistent with previous literature (Hong, Kubik, Stein 2004, van Rooij, Lusardi and Alessie 2007, Nosic and Weber 2009), self-reported risk attitude is highly significant in all three experiments. The control variables: financial literacy, stock ownership, age, education, and income were generally insignificant. Education and income were not collected from the student population since education is relatively constant in the sample and it is difficult to meaningfully assess income in a student sample. See Appendix B for an explanation of the variables used in this and all other analyses. There was no difference in the initial allocation between conditions.

Insert Table 2 here

Driver of increased risk taking: Experience sampling versus distribution displays

Results suggest that adding information through the use of experience sampling and a distribution function leads to more risky asset allocations. This raises the question of whether it is the presence of one or both of these features that results in riskier allocations. This is explored in Experiments II and III by

[9] Results also hold using Tobit regression analysis censored by €0 and €1,000 for Experiment I and $0 and $100 for Experiments II and III.

adding a condition that includes only experience sampling and a condition that only includes distribution functions.

In the experience condition participants first drew returns from the distribution of the two funds separately, in a manner similar to the sampling procedure in Hertwig, Barron, Weber, Erev (2004). Participants had to sample at least three times from the risk free fund (which was always an outcome of $118) and at least eight times from the risky fund and then entered in an initial allocation. Next they sampled from the diversified portfolio of their initial allocation and were able to adjust their allocation and continue to sample until they decided on a final allocation. In the distribution condition, they saw the return of the risk free fund as a line on a graphical display and the distribution graph of returns for the risky fund. The distribution of their initial allocation was displayed graphically. They could change this allocation and see how the distribution graph changed before deciding on their final allocation. See Appendix C for an overview of experimental conditions.

The mean allocations to the risky fund are displayed in Table 3. In Experiment II, risky allocations were elevated in the experience and distribution conditions compared to the description condition, but this difference is only marginally significant for the experience condition compared to the description condition with control variables included in the regression model (see Table 4, column 1). With the increased sample size in Experiment III, the difference between experience and description is significant (see Table 4, column 3).

Insert Table 3 here

Insert Table 4 here

This evidence of the experience-description gap suggests that the increased risk taking in the risk tool is driven more by experience sampling rather than by the presentation of the distribution function. Nevertheless, it does not explain the whole effect, as the difference between the description and combination risk simulation condition is greater than the difference between description and experience conditions. There were no significant differences between the description and distribution conditions (Table 4, columns 2 and 4).

5. COMPREHENSION & UNDERLYING PSYCHOLOGICAL MECHANISMS

Comprehension

We analyzed whether the manner in which people acquire information about risk affects their comprehension of the underlying risk and return profile. The first comprehension question assessed the expected return of the risky fund after five years with an initial investment of $100 in the risky fund. The correct answer based on historical returns is $153. Note that in all conditions except the experience condition, participants were explicitly given the return of the risky fund. Therefore, in order to answer this question correctly, they only had to recall it correctly. Participants choose from among five intervals. The highest percentage of right answers was in the risk tool condition, though this is not significantly higher than any of the other conditions. In order to understand the direction and magnitude of incorrect answers, we created a new variable to reflect overestimation by assigning the value -1 to $100-$140 (the interval that underestimated the return), 0 to $141-$180 (the correct interval), 1 to $181-$220, 2 to $220-$260, and 3 to >$260). Using ordered probit analysis with the control variables previously described, there is significantly less overestimation of the return in the risk tool condition compared to the description condition ($z= 2.28$, $p= .02$). Using the midpoint of each interval to estimate the magnitude of overestimation in each condition, the expected return in the risk tool condition is overestimated by $13 in the risk tool condition and $24 in the description condition (see Table 5).

Insert Table 5 here

Participants estimated the probability that the five year return of a $100 allocation to the risky fund would fall below $100 (correct answer 16%) or exceed $150 (correct answer 54%). Across conditions, participants do not display consistent optimism or pessimism regarding the variance of the return. Overall, there is an overestimation of the chance of receiving a loss (overall mean 29%). On the other hand, there is an underestimation of a return higher than 150 (overall mean 36%).

Additionally, participants were asked to estimate the probability of receiving a loss with the following question: "If we put $100 in the riskier fund, in how many cases out of 100 will final wealth fall below $100 after five years?"[10] In the risk tool condition, they are significantly more accurate about the probability of a loss compared to the description condition using regression analysis with control variables previously described (β=-14.91, $t= 4.69$, $p < 0.01$). Though they overestimate the probability of a loss to a lesser extent, participants in the risk tool condition are not simply more optimistic; they

[10] One observation was dropped because it exceeded 100 (180).

underestimate the probability of a gain at a marginally significant level (β= -6.68, t=1.95, p= .053). Further, recall that those in the risk tool condition are most accurate about the perceived return (and overestimated it to the smallest degree), indicating that they do not appear to have unrealistic expectations about the potential upside return of the risky fund.

The increased comprehension in the risk tool condition is not clearly driven by either experience sampling or the distribution displays. There are no significant differences between the experience, distribution, and description conditions, though the experience condition tends to show a reduced perception of the probability of a loss.

It is especially important to find ways to get people with low financial literacy to understand the underlying risk-return profile of their investments. We divide our sample into high and low financial literacy by splitting participants at mean financial literacy score (which is equal to the median). Across conditions, those with low financial literacy are less accurate about the estimated expected return (t= 1.71, p= 0.09) and the estimated probability of a loss (t= 2.50, p= 0.01). However, participants with low financial knowledge in the tool condition are significantly more accurate about the probability of a loss compared to people with high financial knowledge in other conditions (t(183)=2.09, p=0.04). This suggests that the risk tool holds promise as a tool for financial education.

Psychological Mediators of Risky Allocations

In Experiment III we additionally sought to better understand the psychological process by which the risk tool condition increased risk taking relative to the description condition. The behavioral model of risk taking posits that risk taking is a function of *perceived return* and *perceived risk*, which can be influenced by the decision making context. We assessed these variables and hypothesized that they would mediate the increased risk taking in the risk tool condition. We measured two other psychological variables: confidence in the risky fund and feeling informed about the risky fund. Additionally, as discussed in Section 2, we tested the prediction that the increased risk seeking associated with experience sampling is mediated by the perceived probability of a loss. See Appendix B for measures.

Mediation analysis is a commonly used statistical procedure to elucidate the underlying causal chain from an independent variable (i.e., risk presentation) on a dependent variable (i.e., risky allocation). The objective is to show that the independent variable acts on the mediating variable, which in turn, acts on the dependent variable, as opposed to the independent variable simply increasing both the proposed mediating and dependent variable. Tests of mediation require that four conditions be met (Baron & Kenny, 1986; James and Brett, 1984). To demonstrate the mediating effect of variable *M* in the relation *X* → *Y*: (1) *X* must be significantly related to *M*, (2) *M* must be significantly related to *Y*, (3) the variance in

Y predicted by *X* must be non-significant after mediator *M* is controlled (indicating full mediation) or significantly reduced (indicating partial mediation), and (4) *M* should be significantly related to *Y* after *X* is controlled.

Perceived Risk. After making their allocation decision, participants were asked to report how risky they perceived the risky fund to be on a seven-point scale (anchored at "not risky at all" and "very risky"). This measure of perceived risk partially mediated the increased risk seeking in the risk tool condition compared to the description condition, as indicated by a significant Sobel test[11] ($z = 2.19$, $p = .03$). This is evidence that the risk tool reduces risk perceptions, which in turn increases risky allocations. However, subjective risk perception accounts for only 20.11% of the increase in risk taking, and this partial mediation suggests that there are additional variables that affect this pathway.

Perceived Return. Perceived return was also assessed against a normatively correct benchmark by asking participants to indicate the expected five-year return of a $100 allocation to the risky fund. Since asking participants to simply estimate a figure was likely to lead to highly variable responses, we asked them to choose from among five intervals ($100-$140; $141-$180; $181-$220; $220-$250; >$260).[12] This measure was not found to mediate the increased risk taking in the risk tool condition. The accuracy of this measure is further discussed below in regard to comprehension.

Confidence & Feeling Informed. We hypothesized that participants might feel more informed and thus more confident about investing the risky fund in the risk tool condition and this would underlie the increased risk seeking relative to the description condition. Participants were asked how confident they felt about investing in the risky fund on a seven-point scale. Confidence in the risky fund mediated the increased risk taking in the risk tool condition, accounting for 35% of the variance ($z=2.79$, $p<0.01$). Confidence also mediated the increased risk-taking in the experience condition compared to the description condition, accounting for 40% of the variance ($z= 2.33$, $p= 0.02$).

Feeling informed was assessed by asking participants how informed they feel about investing in the risky fund on a seven-point scale. Though feeling informed and confidence in the risky fund were significantly correlated ($r= .44$, $p<.01$), feeling informed did not significantly mediate increased risk taking in the risk tool condition compared to the description condition ($z=1.38$, $p= .17$).

Perceived probability of a loss. The literature on the experience-description gap theorizes that the overweighting of small probabilities (as described by prospect theory) is reduced or reversed for decisions made from experience. In the case of investment decisions in an equity fund over a five-year horizon (the decision we used in our experiment), the probability of a loss is a small probability. We hypothesized that

[11] For further information about the test, see Sobel, M. E. (1982)
[12] This procedure was used to prevent undue influence from outliers.

the perceived probability of a loss would mediate increased risk taking. This estimation significantly mediates the increased risk taking in the risk tool condition compared to the description condition ($z= 2.24$, $p= .03$) and accounts for 27% of the variation. If we exclude the risk tool condition and examine whether the perceived probability of a loss mediates the increased risk seeking in the experience condition compared to the description and distribution condition, we find marginally significant mediation ($z= 1.85$, $p=.07$), accounting for 24% of the variance.

Summary. Taken together, we find evidence that increased risk taking is mediated by the perceived risk of the risky fund, confidence in the risky fund, and the perceived probability of a loss. Figure 2 displays the means of these variables across conditions and shows the pattern of increased confidence, decreased risk perception, and decreased perceived probability of a loss that is associated with investment allocations.

Insert Figure 2 here

6. Ex-Post Decision Evaluation

Does the manner in which people acquire information about risk influence their satisfaction with their outcomes? Those in the risk tool condition might only be temporarily convinced to accept greater risk and later come to regret their decision, especially if they receive a loss or a return that does not meet their expectations.

After receiving the outcome of their decisions from the financial market simulation, participants reported satisfaction with their return. We find no evidence that people in the risk tool condition regret their relatively high allocations to the risky fund. In all three experiments participants in the risk tool condition were not less satisfied with the outcomes than in the description condition (see Table 6). Even for people whose return fell below the expected value of their allocation decision, satisfaction was not reduced for those in the risk tool condition.

Insert Table 6 here

Another indicator of how people evaluate their allocation decision after receiving their return is their subsequent (hypothetical) allocation decision. Across conditions, there are high correlations between the allocation and subsequent allocation ($r_{Exp1}= .52$, $r_{Exp2}=.70$, $r_{Exp3}=.72$). If we compare subsequent allocations in the description and risk tool conditions, we find riskier allocation in the risk tool condition in all three experiments (see Table 7). These results are robust to the inclusion of control variables.

Insert Table 7 here

That participants again take on more risk in a subsequent allocation in the risk tool condition compared to the description condition suggests that they do not regret their riskier allocation in the risk tool condition. Another way to address the issue of decision regret is to analyze the difference between the first and the subsequent allocation to gain a better understanding of the subjects' reactivity to returns between conditions. Figure 3 plots the subsequent minus the first allocation against the variable luck, which reflects whether subjects earned more or less than their expected return in their final outcome. For example, if a participant invested 100 in the risky fund and received an outcome of 160 in the financial market simulation, the variable luck is calculated as 160 – 153 (which is the expected return) = 7. We combine the data from Experiments II & III, in which participants were allocating $100.

Across conditions, participants are reactive to losses but not gains. They reduce their allocation to the risky fund in reaction to a return less than the expected value of their allocation (i.e., luck <0). This tendency appears less pronounced in the risk tool and experience conditions compared to the description and distribution conditions (see Figure 3). In order to assess this pattern more formally, we focus on the subsample of participants where the expected value falls short of the realized return (i.e. luck<0) and regress the difference between subsequent and final allocation on the interaction terms of the dummy variables for the condition and luck. A higher coefficient suggests that participants reduce their risky allocation in a hypothetical subsequent allocation as a result of a more negative difference between expected and realized return. We find evidence of a lower reactivity to losses in the risk tool condition. Participants are significantly less reactive in the risk tool condition compared to distribution ($F_{(1,314)}$ = 6.59, p= 0.01) and in the experience condition compared to distribution ($F_{(1,314)}$ = 4.26, p= 0.04). Looking at the coefficient in the description condition, we see that participants are more reactive to losses than participants in the experience and the risk tool condition. However, this effect is not significant.

Insert Figure 3 here

Insert Table 8 here

7. Robustness Check of the Experience-Description Gap

In Experiments II & III we observe the experience description gap in portfolio allocation decisions, though it is only marginally significant in Experiment II. Hertwig, Barron, Weber and Erev (2004) invoke two mechanisms to explain the experience-description-gap: reliance on relatively small samples of

information due to limited search (*sampling error*) and overweighting of recently sampled information due to memory constraints (*recency effects*). Fox and Hadar (2006) replicated these results found that the underweighting of rare events in experience-based decisions is almost entirely driven by the sampling error – a discrepancy between objective and experienced probabilities. Similarly, Rakow, Demes and Newell (2008) also claim that sampling error accounts for most, if not all of the gap.

On the other side of the debate, Hau, Pleskac, Keiffer, & Hertwig (2008) found that the description-experience gaps persists when sampling error is eliminated by having participants sample 100 times before making decisions. Abdellaoui, L'Haridon and Paraschiv (2008) elicited the prospect theory weighting function for both experienced and described probabilities. They did find overweighting of small probabilities in the weighting function for experience-based decisions, but to a lesser extent than for description-based decision (in the gain domain only). These results offer some support for the experience-description gap. The less pronounced overweighting coupled with more pronounced underweighting of moderate probabilities for experience-based decisions led them to invoke ambiguity aversion as an explanation for the general pessimism associated with the more ambiguous experienced probabilities. Additionally, sampling error could not account for their results, as sampled probabilities were good representations of the objective probabilities.

We test whether these explanations can account for the increased risk taking in the experience sampling conditions that we find in Experiment III. Specification 1 of Table 9 shows that the difference between experience and description is significant at the 1% level. Specification 2 controls for sampling error with a variable equal to expected value. This variable is equal to the expected value of what each participant actually sampled in the experience condition and is a constant set to $153 in the description condition, as calculated based on historical returns and explicitly stated in the experimental materials. Specification 3 adds the standard deviation, which was standard deviation of sampled outcomes in the experience condition and was explicitly stated in the description condition. After controlling for these variables, we continue to find a significant difference between experience and description. It seems that the effect cannot be fully explained by the sampled outcomes.

Insert Table 9 here

If sampling error drives the results, one would expect allocations in the different conditions to become more similar as information search increases. Hertwig, Barron, Weber and Erev (2004) show that many respondents in the experience group sample rare events less frequently than expected and that the occurrence of the rare event has an impact on choice. (The average number of draws per decision problem was < 10.) In our results we find no effect of the number of stock draws (14.48 on average with a range

from 8 to 109) on the final. Even if we limit the analysis to participants who sampled more than 14.5 times, the higher allocation in the experience condition is still significant (p=0.03). Furthermore, the number of draws does not influence participants' confidence in the decision.

In line with a recency effect, we find a significant influence of the average last three draws participants saw in the experience condition. People who observed a high average of the last three draws make a riskier allocation, but the difference of between experience and description still remains significant when we control for this effect (Specification 4).

In sum, it seems that the experience description gap also exists in portfolio allocation decisions and can not entirely be explained by the number of outcomes sample, sampling error, recency, or active vs. passive sampling.

7. DISCUSSION AND CONCLUSIONS

Research to date had not examined the optimal way to inform customers about the riskiness of investment products in a manner that maximizes comprehension and satisfaction with returns. The results of the current paper suggest that a richer risk presentation format that incorporates experience sampling may help achieve this objective.

Information presentation format reliably affects allocation to a stock fund. Experiments I, II, and III demonstrates that the when the presentation format includes experience sampling and the distribution condition risky allocations are higher compared to simply describing the expected return and standard deviation. In order to determine the type of information that leads to increased risk taking in the risk simulation condition, the distribution and experience conditions were added in Experiment II and III.

Results suggest that it is experience sampling that leads to the riskier allocations in the risk tool simulation condition. Elevated risk seeking was observed in the experience condition relative to the description condition at a marginal level of significance in Experiment II and at a significant level in Experiment III. This confirmation of the experience-description gap may be driven by more accurate weighting of the small probability of a loss. Consistent with this explanation, we find a reduced estimation of the probability of a loss (i.e., a return less than their investment capital) in both the risk tool and experience condition. Further, the estimation of the probability of a loss significantly mediates the increased risk taking in the risk tool condition and at a marginal level for the experience condition. Thus, another contribution of the current paper is the direct measurement of the perceived probability of a loss to give evidence that it does drive the experience-description gap.

Nevertheless, experience sampling does not entirely explain the increased risk-taking in the risk tool condition since risk-taking in the risk tool simulation condition was consistently higher. Presentation of the distribution function may have some additive effect. The distribution function was elevated relative to the description condition in both Experiments II and III, though not significantly. Future research should further explore different graphical presentation formats, perhaps displaying historical returns as percentages as done in Beshears et al. (2010), where significantly higher risk seeking was observed.

Although allocations are higher in the experience and risk tool condition, we do not see any evidence of greater decision regret or unrealistic expectations about the risky fund. Participants in the experience and risk tool conditions are no less satisfied with the return they receive and maintain the same or greater risk level when they are asked how they would allocate their money if they could make a subsequent allocation decision. Comprehension questions revealed that participants in the risk tool condition are most accurate about the expected return and the probability of a loss. Yet, they do not hold unrealistically optimistic beliefs, as they significantly underestimate the probability of a high gain.

Mediation analysis indicates that the increased risk taking in the risk tool condition operates by decreasing perceived risk, increasing confidence in the risky fund, and decreasing the perceived probability of a loss. The addition of decision confidence and the perceived probability of a loss compliment the behavioral finance model of risk taking. It is not surprising that the perceived probability of a loss mediates increased risk taking. The extremely robust literature on loss aversion documents the increased sensitivity to losses relative to gains of equivalent value. In our data, the perceived probability of a loss impacts investment decisions to a greater extent than the perceived probability of a high gain. That increased risk taking is mediated by losses also bolsters the literature on the experience-description gap, which has theorized, but not explicitly measured, reduced overweighting of rare events (in this case the small probability of a loss) for decisions based on experience.

Participants in the experience condition tended to be less reactive to variance in returns. Across conditions, satisfaction with returns follows the shape of the prospect theory utility function (with actual return minus expected return as the reference point). Participants in the risk tool condition tend to show a less steep function in the domain of losses. Similarly, experience sampling tends to decrease the tendency to react to losses by decreasing risky allocations in a subsequent allocation decision.

Taken together, these experiments demonstrate that the provision of richer information about risk results in riskier allocations without any increase in decision regret, greater comprehension, and less reactivity to either positive or negative variations in returns. These results suggest that applying experience sampling through financial simulations may be a productive strategy for banks to improve financial decision making. The recent financial crisis has illustrated the importance of clients fully

appreciating the risk that they accept in their portfolios and the potential losses that can be avoided by not overreacting to market volatility.

References

Abdellaoui, M., O. L'Haridon, C. Praschiv. 2008. Experience-based vs. description-based decision making: Do we need two different prospect theory specification. Working paper.

Baron, G., I. Erev.2003. Small feedback-based decisions and their limited correspondence to description-based decisions. *Journal of Behavioral Decision Making,* 16: 215-233.

Baron, R. M., D.A. Kenny.1986. The moderator-mediator variable distinction in social psychological research: Conceptual, strategic and statistical considerations. *Journal of Personality and Social Psychology, 51*, 1173-1182.

Benartzi, S., R. Thaler. 1999. Risk aversion or myopia? Choices in repeated gambles and retirement investments. *Management Science*., 45, 364-381.

Beshears, J., J. Choi, D. Laibson, M. Madrian. 2009. Can Psychological Aggregation Manipulations Affect Portfolio Risk-Taking? Evidence from a Framed Field Experiment. Working Paper.

Fox, C.R., L. Hadar. 2006. "Decisions from experience" = sampling error + prospect theory: Reconsidering Hertwig, Barron, Weber & Erev (2004). *Judgment and Decision Making*, 1, 159–161.

Glaser, M., M. Weber. 2007. Overconfidence and Trading Volume, *Geneva Risk and Insurance Review.* 32(1), 1554-9658.

Goldstein, D.G., E.J. Johnson, W.F. Sharpe. 2006., Measuring Consumer Risk-Return Tradeoffs. Working Paper.

Hadar, L., C.R. Fox. 2009. Information asymmetry in decision from description versus decision from experience. *Judgment and Decision Making*, 4, 317-325.

Hau, R., T.J. Pleskac, J. Kiefer, R. Hertwig. 2008. The description-experience gap in risky choice: the role of sample size and experienced probabilities, *Journal of Behavioral Decision Making,* 21(5), 493 – 518.

Hertwig, R., G. Barron, E.U. Weber, I. Erev. 2004. Decisions from experience and the effect of rare events in risky choice. *Psychological Science*, 15, 534–539.

Hong, H., J.D. Kubik, J.C. Stein. 2005. Thy neighbor's portfolio: Word-of-mouth effects in the holdings and trades of money managers, *Journal of Finance*, 60, 2801-2824.

James, L.R., J.M. Brett. 1984. Mediators, moderators, and tests for mediation. *J. Appl. Psych*. 69(2) 307–321.

Jia, J., J.S. Dyer, J.C. Butler. 1999. Measures of Perceived Risk. *Management Science*, 45, 519-532.

Kahneman, D., A. Tversky. 1979. Prospect theory: An analysis of decision under risk. *Econometrica*, 47, 263–291.

Keller, C. R., R.K. Sarin, M. Weber. 1986. Empirical investigation of some properties of the perceived riskiness of gambles. *Organizational. Behavior and Human Decision Processes,* 38 114-130.

Klos, A., E.U. Weber, M. Weber. 2005. Investment decisions and time horizon: Risk perception and risk behavior in repeated gambles. *Management Science*, *51*, 1777-1790.

Lejarraga, T. 2010. When experience is better than description: Time delays and complexity. *Journal of Behavioral Decision Making*, 23, 100-116.

Markowitz, H. 1952. Portfolio Selection, *Journal of Finance*, 7, 77-91.

Nosic, A., M. Weber. 2009. Overreaction and Asset Allocation: An Experimental Analysis, Working Paper.

Nosic, A., M. Weber. 2010. How Risky Do I Invest: The Role of Risk Attitudes, Risk Perceptions and Overconfidence, Working Paper.

Oskamp, S. 1965. Overconfidence in case-study judgement, *Journal of Consulting Psychology*, 29(3), 261-265.

Rakow, T., K. Demes, B. Newell. 2008. Biased samples not mode of presentation: Reexamining the apparent underweighting of rare events in experience-based choice. *Organizational Behavior and Human Decision Processes,* 106(2), 168-179.

Rakow, T., B.R. Newell. 2010. Degrees of uncertainty: An overview and framework for future research on experience-based choice. *Journal of Behavioral Decision Making, 23*, 1–14.

Rooij, van M., A. Lusardi, R. Alessi. 2007. Financial literacy and stock market participation, DNB Working Papers.

Sarin, R., M. Weber. 1993. Risk-Value Models," *European Journal of Operational Research*, 70, 135-149.

Sitkin, S. B., A. L. Pablo. 1992. Reconceptualizing the determinants of risk behavior. *Academy of Management Review*, 17, 9-38.

Sitkin S. B., L.R. Weingart. 1995. Determinants of risky decision making behavior: a test of the mediating role of risk perceptions and risk propensity. *Academy of Management Journal*, 38: 1573–1592.

Sobel, M. E. 1982. Asymptotic intervals for indirect effects in structural equations models. In S. Leinhart (Ed.), Sociological methodology 1982 (pp.290-312). San Francisco: Jossey-Bass.

The European Parliament and the European Council. 2004. Markets in Financial Instruments Directive. Directive 2004/39/EC.

Weber, E.U., A.-R. Blais, N. E. Betz. 2002. A Domain-specific Risk-attitude Scale: Measuring Risk Perceptions and Risk Behaviors," *Journal of Behavioral Decision Making*, 15, 263-290.

Weber E.U., R. Milliman. 1997. Perceived risk attitudes: relating risk perception to risky choice. *Management Science*, 43:122–143.

Weber, E.U., S. Shafir, A.R. Blais. 2004. Predicting risk sensitivity in humans and lower animals: Risk as variance or coefficient of variation. *Psychological Review, 111*, 430-445.

Table 1: Overview of allocation to the risky fund – description versus tool condition
This table reports the results mean allocations, standard deviations, and median allocations to the risky fund (out of a possible €1,000 allocation in Experiment I and out of a possible $100 allocation in Experiment II and III) in %.

	Experiment I (Students)			**Experiment II (General Population)**			**Experiment III (General Population)**		
	n	**Initial Alloc.**	**Final Alloc.**	**n**	**Initial Alloc.**	**Final Alloc.**	**n**	**Initial Alloc.**	**Final Alloc.**
Description	75			44			99		
Mean		43.47	**60.42**		52.68	**54.39**		47.95	**57.71**
Std. dev.		30.85	26.34		28.44	26.04		31.84	27.85
Median		45.00	60.00		50.00	50.00		50.00	60.00
Risk Tool	58			45			93		
Mean		44.54	**74.15**		52.27	**66.53**		47.16	**70.59**
Std. dev.		31.68	23.60		25.77	25.50		31.29	26.31
Median		37.50	81.00		50.00	65.00		50.00	75.00
t-test			t=3.12 p<0.01			t=2.22 p=0.03			t=3.38 p<0.01

Table 2: Final allocation to the risky fund – description versus tool condition

This table reports results of OLS regression analysis of final allocations to the risky fund for the risk tool and description conditions. * indicates significance at the 10% level, ** at the 5% level and *** at the 1% level, income expressed in ten thousands, standard errors in parentheses

Allocation	Experiment I (German Students)	Experiment II (General Population)	Experiment III (General Population)
Risk Tool	132.72***	13.83***	11.92***
	(38.42)	(5.24)	(3.64)
Risk Attitude	137.69***	9.72***	10.37***
	(22.63)	(2.93)	(2.00)
Financial Literacy	7.19	1.65	-1.11
	(7.99)	(1.25)	(0.86)
Stock Ownership	-48.85	12.03**	1.77
	(44.72)	(5.69)	(4.16)
Age	16.04**	0.05	0.001
	(6.23)	(0.23)	(1.16)
Gender	31.70	3.49	1.14
	(40.92)	(5.92)	(4.19)
Education		1.97	4.39**
		(2.85)	(2.15)
Income		-1.22	-0.21
		(1.03)	(0.17)
Constant	-189.03	1.96	20.70**
	(156.06)	(14.21)	(9.91)
Observations	133	89	192
R-squared	0.33	0.30	0.21

Table 3: Allocation to the risky fund – all conditions

This table reports the results on mean allocations and standard deviations to the risky fund (out of a possible $100 allocation in Experiment II and III).

	Experiment II		Experiment III	
Condition	**n**	**Final Allocation**	**n**	**Final Allocation**
Description	44	$54.39 ($26.04)	99	$57.71 ($27.85)
Distribution	50	$59.52 ($27.48)	81	$62.46 (27.33)
Experience	50	$61.22 ($24.84)	88	$66.65 (26.62)
Risk Tool	44	$66.34 ($25.77)	93	$70.59 (26.31)

Table 4: Final allocation to the risky fund:
Experience and distribution versus the description condition

This table reports results of OLS regression analysis of final allocations to the risky fund for description and experience as well as description and distribution condition. * indicates significance at the 10% level, ** at the 5% level and *** at the 1% level, income expressed in ten thousands, standard errors in parentheses

	Experiment II		Experiment III	
Allocation	Description and Experience Conditions	Description and Distribution Conditions	Description and Experience Conditions	Description and Distribution Conditions
Experience	8.73*		9.33**	
	(4.88)		(3.87)	
Distribution		7.46		4.35
		(5.39)		(3.77)
Risk Attitude	8.74***	9.90***	5.52**	9.17***
	(2.85)	(3.11)	(2.14)	(2.09)
Financial Literacy	1.44	1.99	0.02	-1.62*
	(1.42)	(1.25)	(0.83)	(0.82)
Stock Ownership	6.90	5.85	-2.46	7.63*
	(5.83)	(6.22)	(4.66)	(4.37)
Age	-0.48**	-0.22	0.21	0.07
	(0.24)	(0.26)	(0.17)	(0.17)
Gender	4.53	-5.69	6.44	6.29
	(5.42)	(6.34)	(4.42)	(4.20)
Education	-0.16	-5.66*	2.01	3.23
	(2.68)	(2.94)	(2.25)	(2.17)
Income	0.29	0.34	-0.53	-0.62
	(0.86)	(0.92)	(0.60)	(0.61)
Constant	24.62*	27.65*	28.74***	26.10**
	(14.34)	(14.98)	(9.91)	(10.39)
Observations	95	94	187	180
R-squared	0.243	0.195	0.104	0.182

Table 5: Comprehension about the risky fund

This table reports the deviation from corrects answers to comprehension questions about the risky fund.

Condition	**n**	**Correct return interval**	**Overestimation of the return***	**Overestimation of the probability of a loss[+]**	**Underestimation of the probability of a gain > $150[+]**
Description	99	46%	$24	21	15
Distribution	81	54%	$27	23	19
Experience	88	47%	$26	15	12
Risk Tool Simulation	93	57%	$13	5	21

*Overestimation of return is estimated from the return intervals by averaging the midpoint of the intervals.

[+] In percentage points

Table 6: Decision satisfaction with returns

This table reports the mean of overall self assessed decision satisfaction (7 point scale) and satisfaction after a return below the expected value of their chosen portfolio.

	Experiment I (Students)			Experiment II (General Population)			Experiment III (General Population)		
Condition	**n**	**Satisf.**	**Satisf. if luck < 0**	**n**	**Satisf.**	**Satisf. if luck < 0.**	**n**	**Satisf.**	**Satisf. if luck < 0**
Description	65 (37)*	4.25 (2.02)	3.03 (1.66)	44 (23)	5.41 (1.59)	4.70 (1.43)	99 (60)	5.25 (1.58)	4.72 (1.63)
Risk Tool	54 (29)	4.10 (1.90)	3.28 (1.94)	44 (26)	5.12 (1.59)	4.54 (1.70)	93 (55)	5.31 (1.62)	4.75 (1.64)

*The n in parentheses reflect the participants with luck < 0.

Table 7: Subsequent Allocation to the risky fund

This table reports the mean, median, and standard deviations of subsequent allocation in % (out of a possible €1,000 allocation in Experiment I and out of a possible $100 allocation in Experiment II and III).

	Experiment I (Students)		**Experiment II (General Population)**		**Experiment III (General Population)**	
	n	**Subsequent Alloc.**	**N**	**Subsequent Alloc.**	**n**	**Subsequent Alloc.**
Description	65		44		99	
mean		64.15		53.77		60.40
std. dev.		25.59		28.30		27.86
median		70.00		50.00		60.00
Risk Tool	58		45		93	
mean		74.58		66.66		68.70
std. dev.		31.68		28.27		24.97
median		84.00		70.00		70.00
t-test for the differences between the means		t=2.25 p=0.03		t=2.14 p=0.04		t=2.17 p=0.03

Table 8: Subsequent Allocation – Final Allocation

This table reports the result of an OLS regression analysis of subsequent allocation – final allocation in Experiment II & III. The sample is limited to when the return was less than the expected return(luck < 0). * indicates significance at the 10% level, ** at the 5% level and *** at the 1% level, income expressed in ten thousands, standard errors in parentheses

Subsequent Allocation – Final Allocation	**Coefficient**	**95% Confidence Interval**
Description * Luck	0.66***	0.46 - 0.86
	(0.10)	
Distribution * Luck	0.77***	0.34 - 0.66
	(0.10)	
Experience * Luck	0.54***	0.36 - 0.72
	(0.09)	
Risk Tool * Luck	0.50***	0.34 - 0.66
	(0.08)	
Constant	12.71	
	(1.93)	
Observations	319	
R-Squared	0.23	

Table 9: Sampling Error and Recency Effects

This table reports the results of an OLS regression analysis of allocations to the risky fund (out of $100) in Experiment II & III including indicators to measure a potential sampling error (expected value and standard deviation) and recency effects (average last three draws). * indicates significance at the 10% level, ** at the 5% level and *** at the 1% level. Standard errors in parentheses. Income is in thousands of dollars.

Allocation	**(1)**	**(2)**	**(3)**	**(4)**
Expected Value		0.17	0.11	
		(0.14)	(0.15)	
Standard Deviation			0.26	
			(0.27)	
Average last three draws				0.17**
				(0.07)
Experience	8.73***	8.71***	8.91***	8.28***
	(3.05)	(3.05)	(3.06)	(3.03)
Personal Risk Estimation	6.31**	6.35***	6.22***	6.15***
	(1.72)	(1.72)	(1.72)	(1.70**)
Gender	6.44*	6.86**	6.98**	6.55
	(3.44)	(3.45)	(3.45)	(3.40)
Age	0.04	0.04	0.03	0.06
	(0.14)	(0.14)	(0.14)	(0.13)
Financial Literacy Score	0.19	0.17	0.18	0.11
	(0.71)	(0.71)	(0.71)	(0.70)
Stocks	0.52	0.74	0.67	1.17
	(3.63)	(3.63)	(3.64)	(3.61)
Education	1.05	0.90	1.03	1.05
	(1.72)	(1.73)	(1.73)	(1.71)
Income/1000	-0.02	-0.02	-0.03	-0.03
	(0.05)	(0.05)	(0.05)	(0.05)
Constant	29.42***	3.54	-1.99	3.45
	(8.09)	(22.17)	(22.93)	(12.97)
Observations	282	282	282	282
R-squared	0.11	0.11	0.11	0.13

Figure 1: Risk Communication Formats

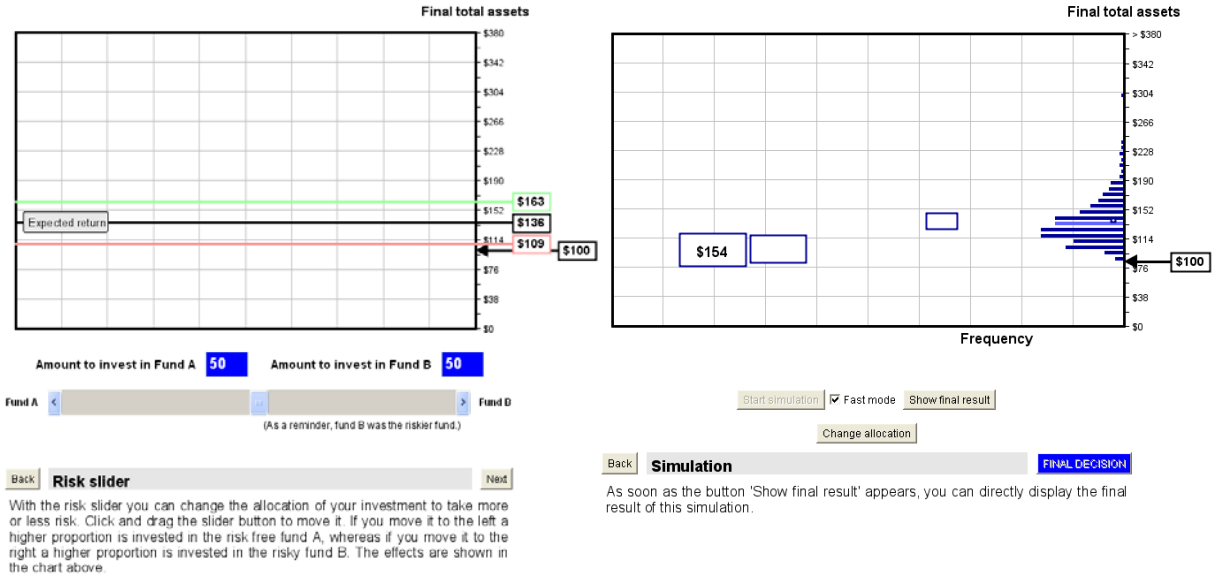


Figure 1a: Risk communication in the Tool Condition via experience sampling and graphical displays

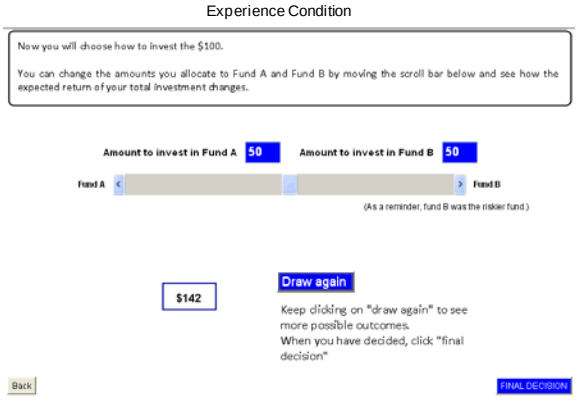


Figure 1b: Risk communication in the Experience Condition

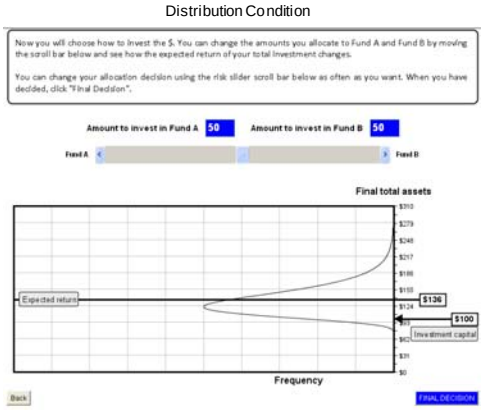


Figure 1c: Risk communication in the Distribution Condition

Figure 2: Graphical overview of main results

This figure reports the mean of allocation to the risky fund and significant mediators. Perceived risk and confidence, originally measured on a 7-point scale are multiplied by 10 to facilitate comparison.

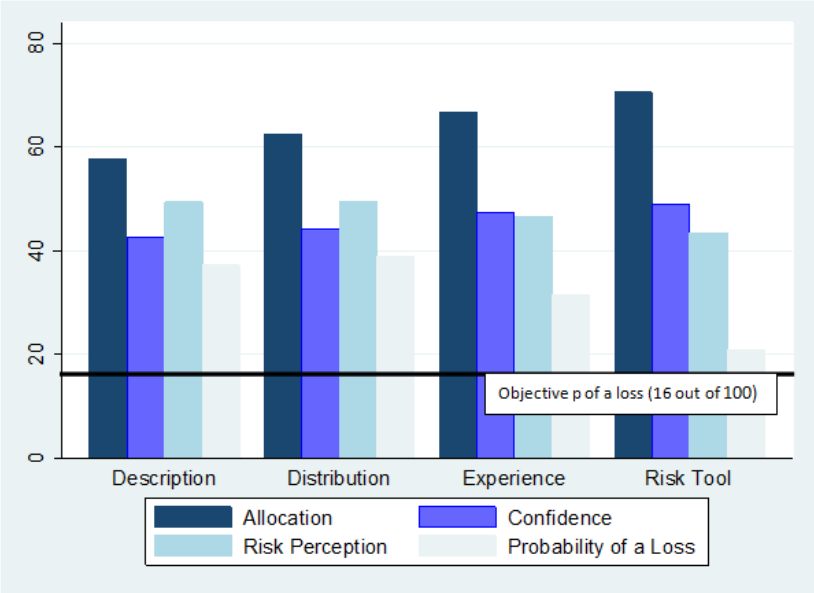
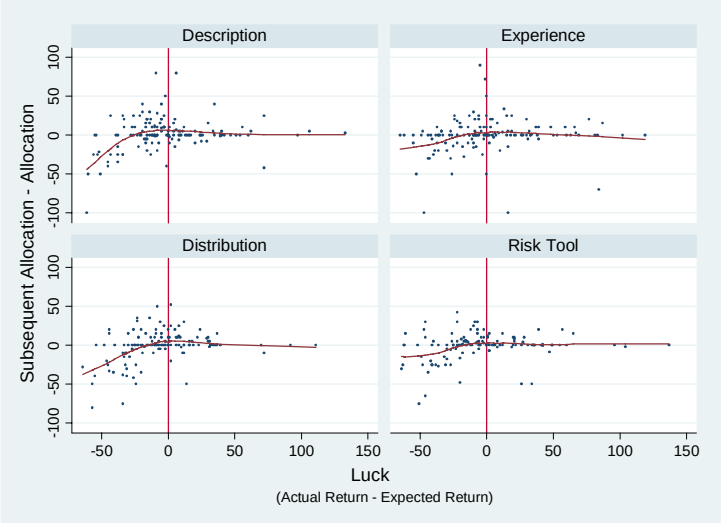


Figure 3: Subsequent Allocation dependent on Investment Success (luck)

Figure 3 reports Subsequent Allocation minus Allocation dependent on luck (outcome of the market simulation minus the expected return), in Experiment II and III combined across all conditions. Outliers are excluded (1% and 99% quantile). Data broken down by condition.



APPENDIX A: Overview of experimental methods

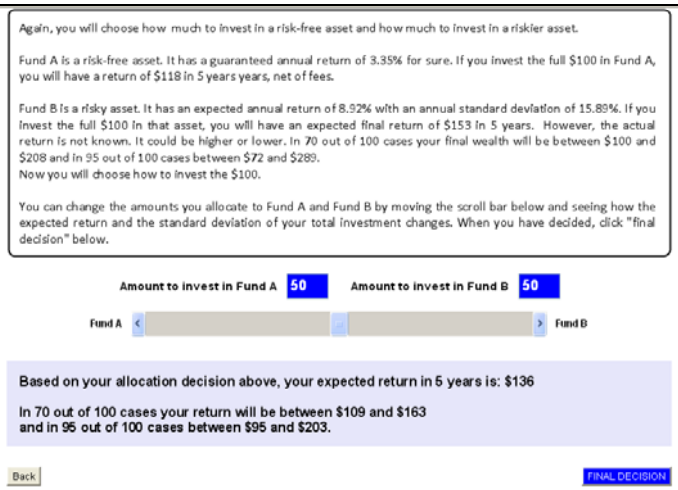
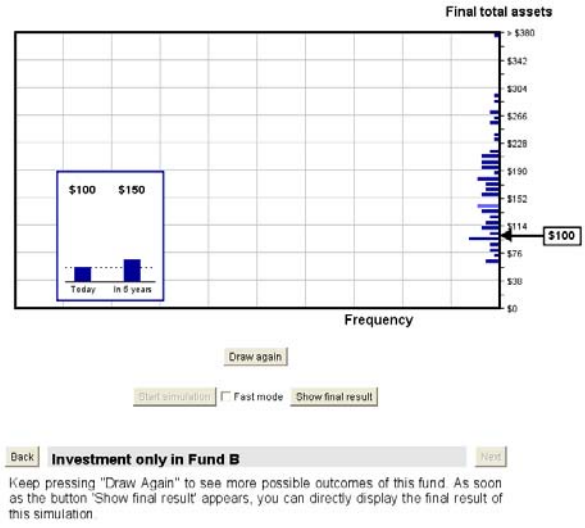
	Experiment I	Experiment II	Experiment III
Conditions			
Description	*	*	*
Experience		*	*
Distribution		*	*
Tool	*	*	*
Questions			
Financial Literacy Questions	*	*	*
Risk Perception			*
Confidence			*
Feeling Informed			*
Comprehension			*

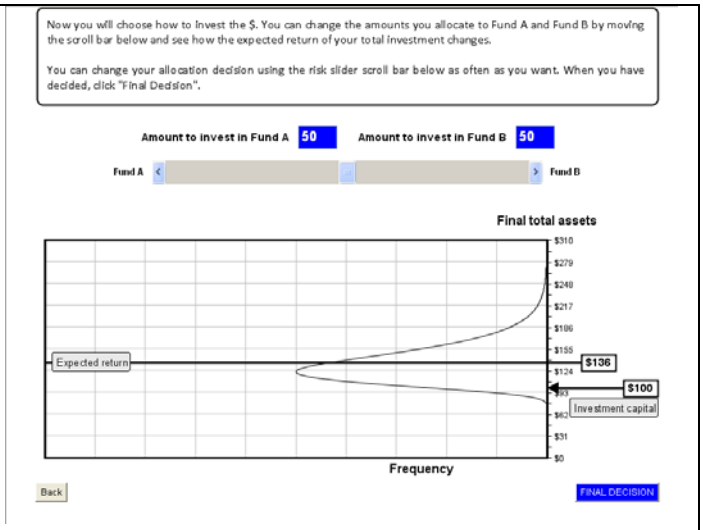
APPENDIX B: Overview of variables and measures

Allocation Variables	
Initial	The first number participants typed in (for the allocation to the risky fund) after they saw the two funds separately.
Allocation	The allocation to the risky fund (out of €1,000 in Experiment I and $100 in Experiment II and III) they selected after being informed about the diversified portfolio return and standard deviation of the initial allocation
Subsequent	The subsequent (hypothetical) allocation they made after seeing the results of the market simulation which potentially determined their payoff (how they would choose again if they had the chance).
Subsequent - Allocation	Differences in (hypothetical) subsequent allocation and allocation decision.
Condition Dummies	
Description	An indicator variable that equals one if the participant was randomly assigned to the description condition, zero otherwise.
Experience	An indicator variable that equals one if the participant was randomly assigned to the experience condition, zero otherwise.
Distribution	An indicator variable that equals one if the participant was randomly assigned to the distribution condition, zero otherwise.
Risk Tool	An indicator variable that equals one if the participant was randomly assigned to the risk tool simulation condition, zero otherwise.
Control Variables	
Risk Attitude	Self reported: Please estimate your willingness to take financial risk (1= Not willing to take accept any risk; 5=willing to accept substantial risk to potentially earn a greater return).
Financial Literacy Score	The score is the sum of the 11 financial literacy questions (highest score 11, lowest 0) adapted from van Rooij, Lusardi & Alessi 2007, a right answer gives one point.
Age	Age of the participant
Gender	An indicator variable that equals one if the gender of the participant is male, zero otherwise.
Stock Ownership	An indicator variable that equals one if subjects own stocks or stock funds, zero otherwise.

Income	Self assessed income of participants in 000 of dollars / euros.
Education	Self reported, 0=some high school or no high school, 1=high school graduate, 2=specific (trade) school/ some college/ associate (2 year) degree, 3=college graduate, 4=advanced degree
Mediating and Comprehension Variables	
Risk Perception	How risky do you perceive fund B (the risky fund) to be? (1=not risky at all, 7=very risky)
Perceived Return	If we put $100 in the riskier fund, what is the expected return of the $100 after five years? (Give your best estimate.) Coded to reflect under- and overestimation: -1=$100 - $140, 0=$141 - $180 (correct interval), 1=$181 - $220, 2=$221 - $260, 3=>$260
Perceived Loss Probability	If we put $100 in the riskier fund, in how man out of 100 cases will the return fall below $100 after five years? In _____ out of 100 cases
Upside Potential	If we put $100 in the riskier fund, in how man out of 100 cases will the return fall be above $150 after five years? In _____ out of 100 cases
Confidence	How confident do you feel about investing in the risky fund? (Experiment III); How confident do you feel about your decision (Experiment 1 and 2); 1= completely unconfident, 7=completely confident
Informed	How informed do you feel about the funds? (1=completely uninformed, 7=completely informed).
Ex-Post Decision Evaluation	
Satisfaction	Question asked after participants were shown their simulated return after five years: How satisfied are you with your return? (1=completely unsatisfied, 7=completely satisfied).
Luck	A variable measuring the outcome of the market simulation minus the expected return of the final allocation.
Experience-Description Gap Robustness Check	
Expected Value	A variable that equals 153 (the objective and stated expected return of the risky fund) in all conditions except the experience condition, where it equals the average sampled return, subjects observed.
Standard Deviation	A variable that equals the stated standard deviation in the description condition and the standard deviation subjects observed through sampling in the experience condition.

APPENDIX C: Overview of experimental conditions

Condition	Information Displayed	Example
Experiments I, II, & III:		
Description	• numerical description of expected return, standard deviation • frequency information used to capture variation	
Risk Tool Simulation	• an experience sampling simulation begins drawing possible returns • these possible returns populate a distribution	
Additional conditions in Experiments II & III:		

Distribution	• graphical display and the distribution graph of returns and stated expected return	
Experience	• participants themselves begin drawing possible returns one by another without building up a distribution function