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Emotions-at-Risk: An Experimental Investigation into Emotions, Option Prices and Risk Perception*

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Abstract

This paper experimentally investigates how emotions are associated with option prices and risk perception. Using a binary lottery, we find evidence that the emotion 'surprise' plays a significant role in the negative correlation between lottery returns and estimates of the price of a put option. Our findings shed new light on various existing theories on emotions and affect. We find gratitude, admiration, and joy to be positively associated with risk perception, although the affect heuristic predicts a negative association. In contrast with the predictions of the appraisal tendency framework (ATF), we document a negative correlation between option price and surprise for lottery winners. Finally, the results show that the option price is not associated with risk perception as commonly used in psychology.

Keywords: Risk perception, emotions, affect heuristic, option prices, experiment

JEL Codes: D81, D03, G17

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I. Introduction

Perhaps the biggest success story of the economic rationality assumption in finance has been the inception of option pricing theory. In their seminal work, Black and Scholes (1973) show how options can be priced using a portfolio of assets that perfectly replicates the option pay-off. Since the law of one price implies that two assets or combinations thereof with the same pay-off should yield the same price, no rational person would accept an option with a different price than that of its replicating portfolio. The value of this rational theory of option pricing extends beyond prices. The observed market price and the Black and Scholes (1973) model combined can be used to infer expectations of future risk (volatility). The 'implied volatility' for several options is used to construct the volatility index (VIX). Many empirical studies document a negative association between changes in the VIX and realized returns, although based on equilibrium models like the CAPM (Sharpe, 1964; Lintner, 1965), one would expect a positive ex ante relation. For instance, Giot (2005) finds a negative relation for the S&P 500 and its corresponding VIX. The same study documents as well a negative association between the NASDAQ 100 index and its volatility index. This effect is also reported by Masset and Wallmeier (2010), who replicate the result using the German DAX index.

Two finance theories try to explain the risk-return paradox using rationality as a starting point. The leverage hypothesis (Christie, 1982) is based on the idea that idiosyncratic or macro shocks to firm value are responsible for the effect. As equities are claims on a company's assets, a decline in firm value leads to increased leverage for equity holders. As a result the volatility of stocks increases after negative shocks to a company's value while it decreases following positive shocks. The volatility feedback hypothesis by French, Schwert, and Stambaugh (1987) and Campbell and Hentschel (1992) argues from the opposite direction, taking volatility as the starting point in explaining the risk-return paradox. In this line of reasoning a shock in volatility causes an increase of the required risk premium. As a consequence, a negative ex post return occurs to accommodate higher future returns.

An alternative explanation of the risk-return paradox comes from behavioral finance. Hibbert, Daigler and Dupoyet. (2008) consider affect to play a major role. Since the VIX is often called the 'fear gauge' by investors (Whaley, 2000), a link to emotions makes intuitive sense. During the last two decades, research is increasingly emphasizing the role of affective factors in risk perception. According to Hanoch (2002) and Muramatsu and Hanoch. (2005) the role of emotions as a source of bounded rationality has been unduly ignored. The risk-as-feelings framework developed by Loewenstein, Weber, Hsee, and Welch (2001) points at the importance of affect for risk perception as well. They argue that emotional reactions to risky situation often diverge from cognitive evaluations. When this occurs emotions often drive behavior. One example is discussed in Kocher, Krawczyk and van Winden (2014) who show that emotions like hope can help explain why many people buy lottery tickets. The affect heuristic for risk and benefit discussed by Finucane, Alhakami, Slovic, and Johnson (2000) and Slovic, Finucane, Peters and

MacGregor (2002) is a prime example of how risk-as-analysis can diverge from risk-as-feelings, with the latter dominating. This heuristic predicts that risk and benefit are negatively associated in people's minds based on emotional evaluation.

Although the affect heuristic may offer a theoretically viable starting point for studying emotions in the context of option pricing, there is very little understanding of the role that affect may play in actual option markets. An essential piece of the puzzle that is missing is an exploration based on direct measurement of affect in the context of option markets. In order to fill this gap, this paper explores the relation between options, risk, and return in an experimental setting. We measure affect directly by letting subjects report their experienced emotions. Many terms related to affect, emotion and feelings are often used interchangeably. Since that makes it somewhat difficult to compare studies (Scherer, 2005), we have decided to measure sixteen individual emotions. This makes it possible to limit the ambiguity of affect and link specific emotions to option pricing and the perception of risk.

To mimic financial markets, we use a binary lottery that provides risky returns in a straightforward way. This simple setup makes it possible to price a financial option by means of the Cox, Ross and Rubinstein (1979) option pricing model. Furthermore, one can test whether a positive or negative return elicits (only) positive or negative effects. We note that this lottery model is incentive-compatible, because the price of options can be determined objectively based on a rational and widely used model. An advantage of our set-up is that emotions are induced by winning or losing the lottery. Zeelenberg, Nelissen, Breugelmans, and Pieters (2008) argue that it is better to study emotions without resorting to exogenous stimuli such as movies or photographs, which are generally irrelevant to the context we are studying. Since gains and losses are common stimuli occurring in actual financial market trading, emotions that are elicited in our experiment are more natural, and better mimic the context of financial markets. In addition to estimating an option price, we also ask subjects to report their subjective perception of risk, a measure of risk that is more akin to psychology.[1] It is measured by a single question on a numerical scale, which according to Ganzach, Ellis, Pazy, and Ricci-Siag (2008) is the best way of measurement. Comparing option price estimates to measures of risk perception makes it possible to compare risk concepts of finance and psychology and helps us understand how these concepts are related. In the remainder of this paper we will refer to risk perception in the sense of the concept from psychology.

We find that emotions are related to both risk perception and option prices, although these measures themselves are not related to one another. These results contrast two basic assumptions often made in the economic literature, namely (i) that risk perception can be captured by option prices and (ii) that emotions are irrelevant for option pricing. Our findings indicate significant associations between

[1] A study conducted by Slovic (1987) illustrates this point. It documents how for lay people risk is correlated to factors such as knowledge and controlability, while risk experts associate it to probability and impact. The empirical heterogeneity in the meaning of risk sharply contrasts the assumptions in the finance literature, where it is commonly defined as the variance or standard deviation of returns.

emotions and option price estimates across experimental conditions. Of particular interest are the results on the emotion surprise, which are consistent with a negative risk-return relation. For those who won the lottery, the correlation between surprise and the option price is positive, while for those who lost the lottery, the correlation is negative. These findings are consistent with a negative association between changes in the VIX and index returns, as suggested by Hibbert et al. (2008). However, they are inconsistent with the appraisal tendency framework (ATF) of Lerner and Keltner (2000; 2001). Their theory emphasizes that emotions are associated with cognitive evaluations of a situation. Appraisals of risk result from evaluations of low control and certainty. Because surprise is associated with both low control and certainty, their theory predicts surprise to be positively related to risk perception, regardless of whether the lottery is won or lost.

The remainder of this paper is organized as follows. In section two we introduce the theoretical perspective offered by finance as well as predictions on the relation between risk perception and option price estimates. In addition we offer two affect-based frameworks, explaining the associations between emotions, returns, risk perception, and option prices. Section three introduces the experiment and demonstrates how insurance on the lottery can be priced. In section four we present our results. The paper ends with a discussion of the results and directions for further research.

II. Theory and Hypotheses

Understanding how the emotion 'affect' is related to risk perception in financial markets requires a good understanding of the concepts used in both psychology and finance. One of the most basic difficulties in economic psychology is that concepts from different fields may often seem simular, but on closer inspection can diverge greatly. This can sometimes cause more than a litte confusion. In tackling this issue, we will start our theoretical analysis from a finance point of view, and then move to a more behaviorally-oriented perspective.

2.1 The Finance Perspective on Risk Perception and Affect

In the finance framework, risk is commonly defined as the variance or standard deviation of returns. This defines risk narrowly and makes it possible to conceptualize risk perception based on the market price of options. Since all variables except the volatility in the Black-Scholes (1973) option pricing model as well as the market price can be observed[2], we can solve for the 'implied volatility' (risk) for which the price based on the model equals the observed market value of the option. In an efficient market, the option price

[2] The variables used in the standard Black-Scholes (1973) option pricing model are: the risk-free rate, the strike or exercise price of the option, the current value of the underlying asset, the volatility of the underlying asset, the interest rate, and the time to maturity. The current market price as well as all other variables excluding the volatility are observable in the market. Consequently, the "volatility" which is "implied" by the market price of the option can be derived from the available information in combination with the Black-Scholes model.

is often considerded the equivalent of risk perception. Seen from this perspective, risk is a straightforward concept that all investors interpret in the same way. Consequently, measures in psychology, like the numerical scale which is considered most valid by Ganzach et al. (2008) should capture exactly the same information as option prices do. This leads us to hypothesis H1.

HYPOTHESIS 1. Risk perception based on a numerical scale captures the same information as option prices, resulting in a statistically significant correlation between them.

Any link between risk perception and affect is not expected in this framework, since theories on option pricing only consider the standard deviation of returns. Risk, from this point of view, is considered a purely mathematical construct which cannot rely on affect. Consequently, no associations between emotions and option prices are expected, which is captured in hypothesis H2.

HYPOTHESIS 2. There are no associations between option prices and emotions.

The traditional view of risk in economics has proven to be extremely useful for the purpose of formulating rational theories of option prices, like that of Black-Scholes (1973) and Cox et al. (1979). However, these theories exclude any possible role for emotions although they are considered important for assigning value to objects (Gifford, 2002). This limits the possibilities of using non-cognitive factors in any traditional finance theory. The standard explanations available to help interpret the empirical finding of a negative association between changes in option prices and the returns on the corresponding index provide excellent examples of these limits. Both the leverage hypothesis (Christie, 1982) and the volatility feedback hypothesis (French et al. (1987) and Campbell and Hentschel (1992)) assume there is a rational explanation for the empirical results, although Hibbert et al. (2008) find them both implausible. Relaxing the rationality assumption, and allowing emotions to play a role in judgment and decision-making, might offer novel insights into risk perception in financial markets.

2.2 Emotions and Risk from a Neuroscientific Perspective

The way emotions are involved in judgements and decsion-making under risk and uncertainty has been studied at length by neuroscientists and psychologists. In the somatic marker hypothesis, discussed by Bechara and Damasio (2005), emotions are an essential part of dealing with risk. The main idea behind this theory is that emotions provide a danger signal. When a risky situation arises, emotion acts as a cue, informing us of possible adversities. Empirical tests with patients who have damage to key areas of the brain show exactly how important our emotions are in avoiding danger. For instance, Bechara, Damasio, Tranel, and Damasio (1997) test the theory by comparing the performance of brain lesion patients with a control group in the Iowa Gambling Task (IGT). In this repetetive game, subjects choose a card from one of four decks. Two of these have a positive expected return, but yield only limited short term gains. The other two have a negative average pay-off, yet result in higher immediate gains. None of the subjects knew which decks were the advantagous ones, so they had to learn along the way. Although normal subjects started to avoid the disadvantagious decks in the experiment, the emotionally impaired patients did not.

A second study conducted by Shiv, Loewenstein, Bechara, Damasio, and Damasio (2005) links emotions to loss aversion, one of the key elements in prospect theory (Kahneman and Tversky, 1979; 1992). In a twenty-round investment task, subjects that had been endowed with $20 chose between investing $1 or nothing in each round. When they did invest, a coin flip determined whether they earned $2.50 or lost their investment. A comparison between participants with damage to the emotion centers of the brain and a control group revealed that the normal patients avoided risk much more often than the brain damage patients.

Although neuroscientific insights contribute greately to assessing the importance of experiencing emotions in judgment and decision making under risk and uncertainty, the studies conducted do have their limitations. The research methodology used in neuroscience is especially useful for obtaining insight into which areas of the brain can be connected to risk processing, i.e., which hardware is operationalised. Based on the somatic marker hypothesis, we can establish that emotions are tools that decision-makers use. However, many emotion theorists in the Darwinian tradition describe specific emotions as programs (Scherer and Ellgring, 2007). The latter approach is helpful for our investigation, since we aim at investigating how specific emotions are involved in risk perception, a goal that has to do with the software rather than the hardware. Consequently, we will look into insights offered by psychologists in formulating further hypotheses connecting risk perception, option prices, and emotions to returns.

2.3 The Affect Heuristic

The affect heuristic model is our starting point from the psychology perspective, in trying to explain the negative relation between return and risk. First documented by Fischhoff, Slovic, Lichtenstein, Reid, and Coombs (1978) while studying perceptions of risks and benefit for 30 technologies, it was noticed that risk and benefit seem to be negatively related in people's minds, although typically positively related in the real world. Finucane et al. (2000) replicated the Fischhoff et al. (1978) experiment and added two important new insights. First, they show how the negative risk-benefit relation becomes more pronounced when subjects are put under time-pressure. This result supports the idea of affect acting as a judgment heuristic. They also find that a positive (or negative) affect regarding benefits lead to more optimistic (or pessimistic) risk judgments. The explanation for these results offered by Finucane et al. (2000) is that of the affect heuristic. Slovic et al. (2002, p. 329) define affect as *"*the specific quality of goodness or badness (i) experienced as a feeling state (with or without consciousness) and (ii) demarcating a positive or negative quality of a stimulus*"*.

The affect heuristic for risk and benefit seems to fit the empirical relation between risk and return documented in financial markets, where positive returns are associated with a decreasing volatility index and a negative return with an increase in the VIX. This contradicts the relation presumed by standard finance theory, with a positive association between risk and return. This results in a paradox of risk and return, which is illustrated in Figure 1.

< Please insert Figure 1 about here >

Figure 1 presents a schematic overview of what might be expected ex-ante for risk and return, based on predictions made by standard finance and the affect heuristic, respectively. Panel A and B show how positive (negative) affect caused by a high (low) return decreases (increases) perception of risk. Panel C and D illustrate the inferences typically made in finance, based on equilibrium models such as the capital asset pricing model (CAPM). The two predict exactly the opposite effect on risk expectations.

Different experiments have documented evidence in support of the affect heuristic prediction of a negative risk-return relation in a finance setting. For instance, Ganzach (2001) provides evidence supporting a negative risk-return relation in several experiments in which subjects had to provide relative risk and/or return estimates for familiar and unfamiliar stock-indices. Although for the better known indices the relation between risk and expected return were revealed to be positive, it was negative for unknown indices. This result is explained by asserting that (lacking sufficient fundamental risk and return information for unfamiliar stock indices) subjects had to base judgments on their general attitude (affect) towards the asset of which they had to indicate both risk and return. Statman et al. (2008) investigate the risk-return relation and provide a link to company affect, using Fortune 500 rankings as a proxy for affect. In an experiment using private wealth management clients, subjects had to indicate how they perceived risk, as well as the expected return on companies in the Fortune 500, based on a numerical scale. Their findings are consistent with the affect heuristic prediction of negative associations between risk and return. A third study by Kempf, Merkle and Niessen-Ruenzi (2013) documents such a negative relation. In their experiment subjects are required to give relative risk and return estimates for DAX-30 companies. By letting subjects estimate what professionals thought was the correct relative ranking of risk and return, they were able to test the risk-return relation in an incentive-compatible way. Kempf et al. (2013) find that the affect heuristic predictions are robust to incentives. Their study also links financial literacy to the strength of the negative risk-return association. Participants in the experiment who performed particularly well on the financial literacy test exhibited a less strong negative risk-return association than those who performed badly.

2.4 Affect and Emotions

Affect encompasses a wide range of phenomena; thus, it is not straightforward to measure it in an experimental setting. We solve this apparent problem by substituting emotions for affect, or, to be more precise, we measure the subjective feeling of emotions. This substitution allows us to use the well-developed apparatus of emotion scientists, without losing any of the predictions for risk perception based on the affect heuristic. We will, however, first justify this substitution by relating affect and emotion to each other.

According to Zeelenberg et al. (2008), affect encompasses a broad class of experiential concepts, including moods, emotions, attitudes, evaluations and preferences. As such, emotions can be seen as a subset of the broader class of affective phenomena. The affect classification by Zeelenberg et al. (2008) is extremely broad and includes many concepts. In order to compensate for imprecision, affect only considers the valence of these experiences. Borrowed from chemistry (Solomon and Stone, 2002), valence is used to describe distinctions of the sort good/bad, pleasant/unpleasant, and positive/negative in a context neutral way (Zeelenberg et al., 2008). Since the affect heuristic explicitly emphasizes the quality in terms of good or bad it is clearly rooted in valence. For the purpose of hypothesis testing, we can simply substitute affect for any other specific affective phenomenon. Consequently, we arrive at hypothesis H3, which is rooted in the affect heuristic.

HYPOTHESIS 3. Emotions with a positive (negative) valence are negatively (positively) associated with risk perception and option prices.

Hypothesis H3 connects valence to option prices and risk perception only indirectly. Explaining the risk-return paradox with the affect heuristic assumes that gains only elicit positive valence emotions while losses only elicit negative ones. We abandon this assumption in hypothesis H4, which links associations between returns, option prices, and risk perception, regardless of emotional valence.

HYPOTHESIS 4. The sign of associations between risk perception and emotions and option prices and emotions is positive (negative) following negative (positive) returns.

With a clear prediction on how risk perception is influenced by emotion in the affect heuristic model, it becomes obvious that findings by Lerner and Keltner (2000; 2001) are at odds with the affect heuristic for risk perception. They analyze how fear and anger are related to risk perception, and document a positive association between risk perception and fear, as predicted by the affect heuristic. However, they also document a negative association between risk perception and anger, which is in contrast with the affect heuristic model. The explanation for this finding makes use of what are called cognitive appraisals, which are not considered in the Slovic et al. (2002) and Finucane et al. (2000) model.

To regard emotions as an empirical proxy for affect makes sense, based on the valence focus of the affect, but this does not mean emotion theorists limit themselves to explanations based on dimension of the emotional experience. In a study conducted by Fontaine, Scherer, Roesch, and Ellsworth (2007), valence only accounts for 35.3 percent of the variation in emotions, while including other dimensions, like control-potency, arousal and unexpectedness, increases the explained variance to 75.4 percent.

Consequently, a valence-only approach would disregard many important components of the emotional experience that are potentially important for risk perception.

Lerner and Keltner (2000; 2001) provide the ATF as an alternative to the affect heuristic model in linking risk perception and emotions. It is explicitly based on factors other than valence to explain how emotions can be associated with risk perception. The ATF asserts that cognitive appraisals are associated with specific emotions. Lerner and Keltner (2000, 2001) assume that each emotion has a unique pattern of appraisal antecedents, which can be linked to risk perception. Based on the six appraisal antecedents[3] used by Smith and Ellsworth (1985), Lerner and Keltner (2000) describe how anger and fear differ on the dimensions of certainty, which is linked to expectations and control. While anger is associated with high control and certainty, fear is associated with low control and certainty. Slovic (1987) identifies exactly the same factors as being important for risk perception. In his experiment, nuclear power is identified as the most dangerous technology out of a list of 30 items. Using a principal component analysis, dread, including perceived control, and unknown, are the two factors found to be most important to risk perception. Being associated with both risk perception, as well as with the appraisals antecedents of emotions, a theoretical link between risk perception and emotions can be easily established. Since both emotions and risk perception share associations to control and certainty they are also associated to each other.

The predictions based on the ATF-framework apply to all discrete emotions. However, an empirical test requires an established pattern of appraisal for each specific emotion, which is not always available. We will deal with this issue by formulating hypothesis H5 in such a manner that it can accommodate all emotions, but limit the scope of our hypothesis testing to the four emotions explicitly addressed by Lerner and Keltner (2000), namely fear, anger, pride, and surprise.

HYPOTHESIS 5. Emotions associated with low (high) control and low (high) certainty antecedents are positively (negatively) associated with risk perception and option prices.

Analyzing risk perception from the perspective of emotions and affect leaves us with two theoretical accounts of the role emotions play in risk perception. The affect heuristic is simple and predicts a negative risk perception and return association but empirical results have shown it cannot account for the negative association between anger and risk perception. The ATF on the other hand provides a framework with a strong theoretical link to the risk perception and emotion literatures. However, it is unclear whether this alternative framework can accurately account for the negative risk perception and return relation.

III. Experimental Design

[3] The six appraisal dimensions in Smith and Ellsworth (1985) are: pleasantness, anticipated effort, certainty, attentional activity, self-other responsibility/control, and situational control.

3.1 Experimental Model

In order to test the theoretical predictions outlined in section II, we will consider a lottery experiment that is well suited for testing the affect heuristic for both option price and risk perception. In order to elicit emotions directed at positive and negative returns, we let subjects play a binary lottery where a player randomly wins or loses with equal probability. Players enter into the lottery by paying a €5 entrance fee out of their €10 participation fee. By drawing an envelope, either €10 or €0 is awarded to subjects. Consequently, net earnings amount to either €5 or -€5. Not only does this setup represent a realistic yet simple representation of risk in financial markets, it also allows us to manipulate emotions within a context comparable to what occurs in actual financial markets. Furthermore, the setup is also sufficiently rich to price a put option on the lottery based on Cox et al. (1979), which pays €5 contingent on losing the lottery and nothing otherwise.

Since we use a put option as the measure of perceived financial risk but also use incentives, subjects had to estimate the objective price of the put option on the lottery. We framed this task as neutrally as possible, by labeling it as lottery insurance. Because we want to apply no-arbitrage pricing for the lottery insurance (see Figure 2), we let subjects estimate the value quoted by an insurance expert. In the instructions it is mentioned that the expert priced the contract assuming the lottery and insurance can be combined as freely as financial assets like bonds and stocks. As a consequence, our setup is also incentive compatible, because there is a correct answer for which we can reward subjects who estimate the price correctly. Figure 2 shows graphically how the insurance on the lottery can be priced using just cash and a position in the lottery.

< Please insert Figure 2 about here >

Figure 2 presents a schematic overview of the replication strategy underlying the reasoning of the insurance expert in determining the value of the insurance contract, which in finance jargon is actually a put option. The option price is obtained in three consecutive steps, represented by each of the three panels in Figure 2. In the leftmost panel, the payout in the lottery is shown. Subjects earn either €10 or €0, represented by the up- and down-nodes, respectively. Subtracting the €5 fee a player has to pay for entering into the lottery from the payout in each of the two possible states of the world results in the pay-offs represented in the leftmost equation in Figure 2.

In step two, which is represented in the middle panel, the delta represented by the symbol Δ is calculated. Theoretically, one can hold every possible position in the lottery, including a fraction Δ for which the up-node minus the down-node for the position in the lottery and the lottery insurance are identical. Since the lottery insurance protects against losses in the lottery, the insurance pays out €5 in case a player loses the lottery and €0 if she wins. Consequently, Δ is equal to -0.5, which is shown in the middle panel. Holding this theoretical position in the lottery results in a payout of -€5 when a player wins, and €0 when she loses the lottery.

In the rightmost panel we show the final step in constructing a portfolio, which replicates the lottery insurance payout and price. We add €5 in cash to the portfolio, which is exactly the amount needed to duplicate the €5 and €0 insurance payouts contingent on losing and winning, respectively. The costs for the replicating strategy can be easily derived. The entrance fee for the lottery is €5. Because we hold a position of -0.5 in the lottery, we need to pay €5 * (-0.5) = -€2.50. In addition, €5 in cash is included, which means the total costs of replicating the insurance lottery sum up to -€2.50 + €5 = €2.50. The law of one price now dictates this price is also the only rational price for the put option,

3.2 Experimental Conditions and Procedures

In total 96 students participated in the experiment, which is a two-condition (win or lose the lottery) between-subject design. All subjects were enrolled in either the Master of Science (MSc) in Finance or the MSc in Financial Management at the VU University Amsterdam. Exactly 25 percent of the subjects had participated in an economics experiment before. About one third (34) of the total were female. On average, subjects earned €12.05 based on a show-up fee of €10, the result in the lottery (either +€5 if subjects won or -€5 if subjects lost), and their performance in an option valuation task (maximum of €5, minimum of €0). The minimum amount subjects earned was €5, while the maximum amount was €20. The experiment lasted 45 minutes.

The experiment was conducted in two groups. Aside from the timing of payment, the experimental procedures between the two groups were identical. In the first group (n = 61) subjects received payment exactly a week after the experiment was conducted, while in the second group (n = 35) they received their payments directly after the experiment. The rationale for using different payment conditions is to investigate possible differences in effort between the two groups. Based on the findings by Prelic and Loewenstein (1992) people discount hyperbolically, and consequently tend to place extreme weight on present outcomes over future outcomes. Delaying payment by a week might therefore diminish the weight given to the incentives. If we find differences between the intensity of emotions under the direct versus delayed payment conditions it allows us to attribute these results to the effort of earning money, rather than risk perception. It also has the advantage of keeping the task completely incentive-compatible.

In all conditions after entering the room, subjects were given written instructions regarding the lottery and the payment procedures. The experiment was conducted in four rounds. During each round, a time limit was applied, although all subjects finished well before the limits expired. In the first round all participants had to buy a lottery ticket for €5. All subjects had the opportunity to select their own lottery tickets from a plastic box, presented to them by one of the experimenters, emphasizing we had no influence on the outcome in the lottery. The amount of winning and losing lottery tickets in the box was 50 for both groups, resulting in an equal gain and loss probability. In total 47 subjects won the lottery while 49 ended up with losing tickets. Figure 3 schematically summarizes the rounds over which the experiment was conducted.

< Please insert Figure 3 about here >

Figure 3 shows an overview of the sequence of events in the experiment. After all the subjects were aware of the lottery result, the second round started. Experimenters again provided subjects with an envelope, this time containing a questionnaire regarding the lottery they had just participated in. In addition to providing self-reports of 16 emotions – according to Robinson and Clore (2002) the most common and potentially the best way to measure emotions - including admiration, anger, anxiety, contempt, envy, fear, gratitude, guilt, irritation, joy, pride, regret, sadness, shame, surprise and their mood, the questionnaire also asked subjects to evaluate the lottery riskiness on a 7-point scale. After all subjects had filled out the questionnaire, they handed in the envelopes and received the envelope for the third round. This round consisted of valuing a put option on the lottery, paying exactly the €5 that was at stake in the lottery in case a player loses. This task was framed as neutral as possible, by labeling the put option as an insurance contract. Subjects were informed about the way they could earn extra money by correctly estimating the quote by the insurance expert. They were asked to provide an estimate for the insurance price in eurocents and informed they would receive €5 for a correct answer. In addition it was explained that for each cent their estimate deviated from the correct price €1 would be subtracted, with a minimum earning of €0. Consequently, answers between 245 and 255 resulted in payments to participants in this part of the experiment. During the fourth and final round, a questionnaire was presented to the subject consisting of a literacy test, partially based on Van Rooij, Lusardi, and Alessie (2011)[4], and some additional more general questions. These included how much subjects would be willing to pay for the insurance contract, information about their gender, as well as a question regarding whether they perceive themselves more as savers or investors. A full description of the procedures and questionnaires is provided in the Appendix.

IV. Results

4.1 Earnings and Manipulation Check

[4] We used the basic financial literacy test developed by van Rooij et al. (2011), which contains five multiple choice questions testing basic knowledge, e.g., inflation and interest. The test is also used by Kempf et al. (2013) who finds that literacy is related is positively related to the size of the negative risk perception-return association

Before we discuss the results in terms of the hypotheses formulated in section II, we will consider some general observations. During round 3, subjects estimated the value of insuring against a loss in the lottery that had to be reported in eurocents. Based on the reasoning in paragraph 3.2 the correct answer to this question was 250 cents. On average the given quote was 237 eurocents. Women were closer to the correct price with an average estimate of 246 cents compared to men at 233 cents, although a Mann-Whitney test shows this result is not significant (p = 0.89). At first sight, it may seems odd that there are no significant differences between the averages, but this is explained by substantial dispersion in estimates that range between 0 en 500 eurocents.

Based on the estimated insurance price, subjects were rewarded. For providing the correct quote, €5 was earned. For each cent their estimate differed from the correct price, €1 was subtracted from the maximum fee. The minimum earnings in the task are set at €0. Consequently, answers in the 245–255 cents range resulted in payments to subjects in this task. The complete distribution of earnings in the insurance valuation task is provided in Figure 4.

< Please insert Figure 4 about here >

The mean of earnings in round 3 was € 2.16. Based on the distribution of earnings, provided in Figure 4, it is clear that subjects provided mostly either exactly the right price or their estimates fell far outside the earnings range. Most participants gave answers well outside the 245–255 eurocents range and consequently did not earn anything. Out of the 95 estimates[5] 93 subjects earned nothing or one euro.

OBSERVATION 1. The distribution of earnings in the option pricing task is mostly binary: subjects either earned the maximum amount or they earned nothing.

To the best of our knowledge this paper is the first one that uses an option price to measure risk perception. Consequently, there is no clear empirical benchmark for the dispersion of option price estimates. Two interesting things stand out. First, almost half of the subjects provided the correct estimate of the option value. Secondly, almost all subjects that gave incorrect estimates did not even come close to the actual price. These participants most likely failed to recognize the possibility of applying the replication strategy, outlined in section 3.1. This implies that subjects may have used very different estimation strategies. Possibly, emotions could have been used as a source of information for finding the right option price. This interpretation is consistent with the risk-as-feelings approach suggested by Loewenstein et al. (2001). In section 4.2 we analyze whether emotions can explain part of the observed dispersion in the incorrect estimates.

[5] The estimate of 1 subject had to be disregarded in the analysis of the option price estimates because no subject number was provided on the form used in round 3.

Next we turn to possible differences between payment conditions. The first group received their payment exactly a week after the experiment, and the second group during (participation fee and earnings/losses in the lottery) and after (performance fee in the option pricing task) the experiment. A Mann-Whitney test of equal means indicated no significant differences between the groups for option price estimates ($p = 0.35$) and risk perception ($p = 0.97$). To test for possible differences in distributions for the two indicators of risk we performed the Kolmogorov-Smirnov test. Again no differences were found for the option price estimates ($p = 0.84$) and for the risk perception ($p = 1.00$). We conclude that delayed payment did not influence behavior in any substantial way. In addition, we also performed the Mann-Whitney and Kolmogorov-Smirnov tests for each reported emotion, in order to test for possible differences between payment conditions. For none of the emotions we obtained significant results.

OBSERVATION 2. Delayed payment does not affect option price estimates, risk scores or emotions in terms of means or distributions.

In a next step we analyze whether the elicitation of emotions depends on winning or losing the lottery. The results regarding the impact on self-reported emotional states are reported in Table I.

< Please insert Table I about here >

Table 1 shows the self-reported average emotions experienced by subjects, as well as the standard deviation. Affect was measured directly following the resolution of the lottery for lottery winners and losers respectively. The intensity scale ranges from 1 (no emotion) to 7 (high intensity). We find the mean of positive emotions, gratitude, and joy to be significantly higher for lottery winners than for losers ($p < 0.01$). In addition the results suggest a significantly higher experience of pride ($p < 0.05$) in winners than in losers. For negative emotions we find significantly higher means ($p < 0.01$) in losers compared to winners for anger, disappointment, irritation, regret, and sadness. Table 1 indicates that for the ambivalent emotion surprise we find a significantly higher mean for winners ($p < 0.01$). We conclude that winning or losing the lottery does indeed elicit emotions in subjects.

OBSERVATION 3. There are significant differences in the emotional experience between winners and losers of the lottery.

One of the more implicit assumptions underlying any framework linking affect or emotions to returns is that emotions are actually elicited. Indeed, gaining or losing money translates in an emotional experience which in turn could be related to option price estimates and risk perception.

4.2 Emotions, Risk Perception and Option Price Estimates

In this section we discuss the results obtained for associations between emotions, risk perception, and option price estimates. The results are summarized in Table II, and are presented for both option prices and risk perception separately. In addition, we also investigated possible correlations between risk perception/option prices and other variables. These included energy mood, basic financial literacy and option literacy. No significant correlations are revealed.

< Please insert Table II about here >

Table II shows the Spearman rank correlation between emotion and risk perception and emotions and option price estimates, respectively. The intensity scale for emotions ranges from 1 (no emotion) to 7 (high intensity), the risk score ranges from 1 (no risk) to 7 (very risky), while the option prices were taken as estimated insurance price measured in eurocents. For each of the two measures of risk we assessed significance of correlation for i) the total sample, ii) the lottery winners only, and iii) the lottery losers only, which means we report 6 correlations per emotion.

Risk Perception & Option Price Association

The first thing we notice when we look at Table II is that none of the emotions that are significantly associated with the risk perception are also significantly associated with the option price estimates. Consequently, we question whether subjects perceive option prices and risk perception as equivalent measures. If these measures were related, we would at least expect some significant correlation between them. However, our analysis reveals no such relation. For the sample as a whole, the Spearman rank correlation is nearly equal to zero ($\rho = 0.06$, $p = 0.54$). One explanation for the lack of correlation could be knowledge of option pricing. Subjects who understand how to calculate the correct price can provide the answer without relying on the risk they perceive. Although a Spearman rank correlation test excluding correct estimates shows a slight increase in correlation ($\rho = 0.13$), this result is not significant ($p = 0.33$). Consequently, we reject hypothesis H1.

RESULT 1. In contrast to the finance perspective on risk perception, we find no statistical evidence that risk perception is captured in option prices or vice versa.

The implications of result 1 are relevant for those who interpret option prices as risk perception, or who try to link existing theories from the psychology literature on perceived risk to financial markets. Our findings reveal no support for such a cross-field use of concepts. Ganzach et al. (2008) argue that the best measure for perceived risk is a single question on a numerical scale. Although such a measure is useful in studying to what extent agents find a situation, asset or technology risky, it is not helpful if the goal is to study option prices and their associations to returns. For this we need to treat option prices as a concept that is distinctly different from risk perception. Consequently, both risk perception and option prices are useful in studying risk, but which one should be used strongly depends on the specific research goal.

Before explaining specific associations, we first discuss the general prediction from the field of finance that emotions are not associated with option prices (hypothesis H2). We exclude from the analysis subjects who have provided correct estimates and are consequently likely to know how to price the option analytically. Since subjects who correctly priced the option do experience emotions but most likely did not base their judgments on them, excluding these observations simply avoids analyzing noise. Our analysis provides a clear picture of the connection between emotions and option prices when the correct price for a contract is too complicated to know, just like in the real world. Table II shows that H2 is rejected because for lottery losers we find that the correlation between option price and emotion is significant for envy ($\rho = -0.42$; $p < 0.05$) and surprise ($\rho = -0.46$; $p = 0.01$). In addition, the correlation between surprise and option price is significant for lottery losers ($\rho = 0.45$; $p = 0.02$). The interpretation of the sign of these correlations will be discussed later in this section.

RESULT 2. We find statistically significant evidence supporting associations between emotions and option price estimates.

Table II shows in the leftmost column that the Spearman rank correlations are significant and positive for gratitude[6], joy, and admiration ($p < 0.05$), based on the total sample ($n = 96$). Since all three emotions represent positive valence for which the affect heuristic predicts negative associations, these results contradict our hypothesis H3.

RESULT 3. In contrast to the affect heuristic prediction of negative associations, we find positive associations between risk perception and the positive emotions admiration, joy, and gratitude, respectively.

Differentiating between lottery winners and losers, we find the associations between separate emotions and risk perception can primarily be attributed to lottery winners ($n = 47$). Table II shows that both gratitude ($p < 0.01$) and admiration ($p < 0.05$) are significant only for lottery winners. A similar result is obtained for joy, which only slightly falls below the 5 percent significance level ($p = 0.052$). Gratitude emphasizes the praiseworthiness of the actions of an agent with respect to a desirable event, thereby making it the opposite of anger, which is characterized by the blameworthiness of the actions of an agent with respect to an undesirable event (Ortony, Clore and Collins,, 1988). Since these two emotions represent each other's opposite, a different sign for their association to risk perception should not be surprising.

These results show that valence is a poor predictor of associations between risk perception and emotions, as Lerner and Keltner (2000) already suggest. Although Slovic et al. (2002) admit the limitations of their model, we still feel it is becoming increasingly difficult to justify using the affect construct, given the growing amount of evidence against the model from the emotion theory field.

[6] According to Ortony et al. (1988), gratitude is a compound emotion arising from a combination of both joy and admiration.

Table II documents significantly positive associations between anxiety and risk perception for lottery winners ($p < 0.05$) only. For fear, which is highly related to anxiety[7], we find similar results, but only significant at the 10 percent level ($p = 0.097$). Although in this instance the valence and the sign are in line with the affect heuristic as well as the ATF predictions, the result is at odds with a negative association between risk and return as proposed in hypothesis H4, since we find the anxiety-risk association only for lottery winners. This pattern suggests a positive association between risk and return.

RESULT 4. In contrast to the affect heuristic prediction of negative associations, we only find a positive correlation between risk perception and emotions for lottery winners.

To be consistent with both the empirical findings on the risk perception and index return association, an affect heuristic explanation requires i) positive (negative) returns that are positively (negatively) associated with positive (negative) affect, and ii) that positive affect is negatively (positively) associated to risk perception. These predictions of the affect heuristic are formally represented by hypotheses H3 and H4, but are rejected in our study. For the affect-based framework this is problematic, but it does not invalidate a role for emotion in option pricing, since our result R1 hinted that risk perception and option price estimates are found not to be related in our setting. For any conclusion on associations between gains and losses in the lottery and corresponding associations, we should look at the link between experimental conditions and option prices more directly.

Table II shows significant associations between envy and option price estimates for lottery losers ($\rho = -0.42$; $p < 0.05$). Envy emphasizes the good fortune of others and is also linked to motivating subjects to improve their current situation[8]. This finding contrasts our hypotheses H1 and H2. First, envy is a negative valence emotion, for which the affect heuristic for risk perception predicts a positive sign (H3), while we find a negative one. Secondly, the negative association follows a negative return. Since the sign of the correlation is negative and the return is negative as well, a positive association between option price and return results from envy, while the affect heuristic (H4) would predict the opposite.

Based on the total sample, we find no significant association between surprise and either option price estimates or risk perception. Zooming in on lottery winners and losers separately reveals some significant results, but only for option price estimates. While the association between option prices estimates and surprise is negative for lottery winners ($\rho = -0.46$; $p = 0.01$), it is positive for losers ($\rho = 0.45$; $p = 0.02$). The changing sign seems to indicate that two types of surprise[9] were experienced: pleasant surprise (winners) and unpleasant surprise, i.e., shock (losers). For both pleasant and unpleasant surprise the pattern predicted by the affect heuristic holds nicely. The sign of the correlation coefficient matches

[7] Ortony et al. (1988) categorize both fear and anxiety as fear-type emotions. The Spearman rank correlation coefficient for fear and anxiety in our experiment equals 0.61 ($p = 0.00$).

[8] Zeelenberg et al. (2009) link envy to increased effort. The emotion emphasizes the good fortunes of others, and is negative in valence.

[9] Ortony et al. (1988) do not consider surprise itself an emotion, because it has a neutral valence. They do however consider pleasant surprise and unpleasant surprise emotions.

the valence prediction in the affect heuristic. In addition, positive emotion results from a positive return, while negative emotion results from a negative return. Surprise constitutes the only instance in which hypotheses H3 and H4 both hold, while hypothesis H5 is rejected[10].

RESULT 5. We find that pleasant (unpleasant) surprise follows positive (negative) returns and pleasant (unpleasant) surprise is positively (negatively) associated with option price estimates.

The results on surprise, the emotion most closely linked to unexpectedness (Fontaine et al., 2007), points at the importance of emotions in crisis situations. For instance, during the global financial crisis in 2008, option prices reached new highs while returns were extremely negative. Interestingly, also the ATF framework of Lerner and Keltner (2001) seems inconsistent with these findings. However, this framework is much more precise in terms of explaining associations. In this theory, associations are all about risk perception, which is important since result R1 shows option prices are not associated to risk perception in our experiment. Consequently, on closer inspection the result R5 does not invalidate the ATF, because the theory is not about option prices.

V. Discussion

Our results are clearly not in line with the standard view of finance on risk and rationality. We find that risk captured by option prices is not related to subjective risk perception measured on a numerical scale. Moreover, emotions appear to be associated with both types of risk measures, although for each measure a different set of emotions seems relevant. Our findings shed some doubts on the assumptions of theories explaining the negative risk-return relation. For example, in traditional economic models it is assumed that only actual changes in the volatility of returns can influence risk perception and option prices. Consequently, our study shows that taking affect into account in the field of derivatives may help us better understand risk in financial markets. The role of affect should not be dismissed too easily. Although in our experiment risk was held constant, we found several statistically significant associations between emotions and option prices.

The application of insights from psychology to option prices, however, is far from straightforward. Our results indicate that psychological risk measures do not map one-to-one to financial markets, where risk is defined in terms of option prices. The implication is that researchers who study risk and/or risk perception should pay careful attention to the specific measures used. If the objective is to explore risk in financial markets, one should be aware that option prices are not the same as subjectively perceived risk. For the latter, it may be more appropriate to use a numerical scale.

We began this study with the empirical observation that risk and return often appear to be negatively related in financial markets. Finucane et al. (2000) suggest that affect may explain this negative

[10] Lerner and Keltner (2000) predict a negative sign, regardless focusing on appraisals of unexpectedness.

relation, but they could not rule out a cognitive explanation, partly because they did not measure affect directly. Since we measured affect directly with self-reported emotions, we are able to provide more evidence of the role of affect. In this light, our findings on the emotion surprise are of particular interest. The associations we found between surprise and option price estimates are consistent with the empirical findings. For those subjects who won the lottery, surprise is positively associated with option prices, while for lottery losers the opposite holds. Surprise is elicited by unexpectedness (Fontaine et al., 2007) and has previously been studied in economics in the context of gift giving (Ruffle, 1999).In finance surprise seems especially relevant in turbulent financial markets. Our results suggest that surprise may be a natural starting point for behavioral finance researchers who want to better understand how emotions affect option pricing. More generally, our results show that it is important to go beyond emotional valance and look at how individual emotions influence behavior and risk perception. We found that positive emotions like joy and admiration are positively related to risk perception – a result which is clearly inconsistent with the affect heuristic of Slovic et al. (2002).

There are still many issues for further investigation. For example, future research may focus on very specific emotions (like surprise) that seem relevant for understanding risk in financial markets. Because large market movements are almost always the result of unexpected events, the negative risk-return association could be stronger when changes in returns are more extreme. Introducing more time-pressure in follow-up experiments might enhance affective processing and produce even stronger results, as suggested by Finucane et al. (2000). On the other hand, a cooling-off period might reduce the role of emotions, because the duration of emotional intensity is generally short (Beedie, Terry and Lane, 2005). Research by van Winden, Krawczyk, and Hopfensitz (2011) shows that the timing of lottery resolution influences investment decisions, so it would make sense that such timing effects can also influence option price estimates. Another avenue for future research would be to use different risk measures. In our experiment we measured risk through option prices. An alternative would be to frame risk as volatility, which may make risk more salient and possibly stronger related to psychologically experienced risk. Finally, it may be interesting to use real option traders in experiments. Although we used subjects that study finance (including options), they lack experience in real financial markets. The literature suggests that traders may even be more prone to (irrational) behavioral than regular people (Haigh and List, 2005). However, they are more experienced in interpreting the VIX index, and consequently much more aware of the connection between risk perception, implied volatility and option prices compared to our subjects.

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Table I

Differences in Experienced Emotions between Winners and Losers

This table shows the self-reported average emotions experienced by subjects, as well as the standard deviation as measured directly following the resolution of the lottery. The winners earned €5, while the losers lost €5. The intensity scale ranges from 1 (no emotion) to 7 (high intensity). We employ a two-tailed Mann-Whitney test with the null hypothesis of no significant difference in mean between lottery winners and losers: ** p < 0.01, * p < 0.05.

	Lottery Winners (n = 47)		**Lottery Losers** (n = 49)	
Emotion	**Mean**ǂ	**Stand. Dev.**	**Mean**ǂ	**Stand. Dev.**
Admiration	2.60	1.65	2.23	1.70
Anger**	1.33	1.00	2.27	1.66
Anxiety	2.81	1.82	1.54	1.54
Contempt	1.83	1.40	2.23	1.60
Disappointment**	1.40	1.40	3.58	1.74
Envy**	1.08	0.35	2.35	1.66
Fear	1.85	1.41	1.63	1.30
Gratitude**	3.46	2.19	2.02	1.55
Guilt	1.31	0.88	1.17	0.56
Irritation**	1.69	1.40	2.63	1.75
Joy**	4.17	1.71	2.90	1.64
Pride*	2.46	1.47	1.98	1.48
Regret**	1.40	1.30	2.29	1.92
Sadness**	1.10	0.47	1.94	1.52
Shame	1.15	0.55	1.25	0.64
Surprise**	4.46	1.84	2.60	1.65

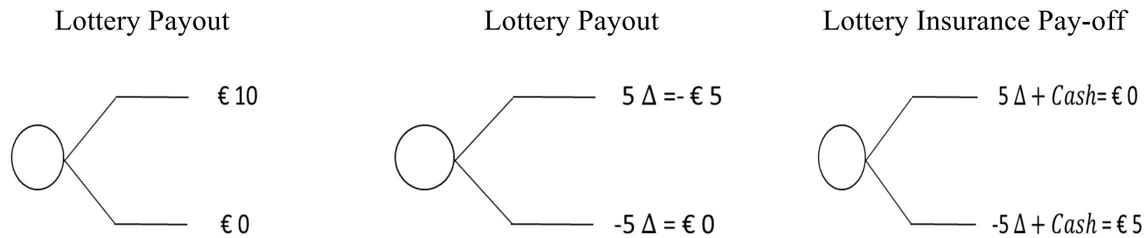
Table II

Rank Correlations between Emotions and Risk Perceptions

This table shows the Spearman rank correlation between emotions and risk perception and emotions and option price estimates, respectively. The intensity scale for emotions ranges from 1 (no emotion) to 7 (high intensity), the risk score ranges from 1 (no risk) to 7 (very risky), while the option prices were taken as the estimated price measured in eurocents. For each of the two measures of risk perception we have assessed significance of correlation for i) the total sample, ii) the lottery winners only, and iii) the lottery losers only; ** $p < 0.01$, * $p < 0.05$, Spearman rank correlation test of no correlation; sample sizes for risk scores: total sample: n = 96, lottery winners: n = 47, lottery losers: n = 49. For the analysis of associations between option price estimates and emotions we excluded correct option prices (n = 40) from the analysis. Total sample incorrect option price: n = 55, lottery winners: 27, lottery losers: n = 28.

	Risk Perception			Option Price Estimates		
Emotion	Total sample	Winners	Losers	Total sample	Winners	Losers
Admiration	0.24*	0.30*	0.18	0.10	-0.10	0.30
Anger	-0.09	-0.08	0.00	-0.16	0.06	0.30
Anxiety	0.12	0.34*	-0.12	-0.04	-0.18	0.18
Contempt	-0.04	-0.01	-0.04	0.00	0.17	-0.17
Disappointment	-0.15	-0.16	0.03	-0.06	-0.11	0.09
Envy	0.03	0.11	0.12	-0.26	-0.08	-0.42*
Fear	0.15	0.24	0.02	-0.07	-0.12	-0.04
Gratitude	0.22*	0.40**	-0.04	0.12	0.20	0.00
Guilt	0.16	0.03	0.28	0.06	0.34	-0.25
Irritation	-0.05	-0.03	0.04	-0.03	0.19	-0.29
Joy	0.23*	0.29	0.13	0.04	-0.05	0.08
Pride	0.25	0.18	0.26	0.04	0.04	0.04
Regret	0.11	-0.03	0.26	-0.04	0.23	0.22
Sadness	0.01	0.09	0.06	-0.04	-0.02	0.08
Shame	0.03	0.13	-0.01	0.06	0.14	-0.02
Surprise	0.01	0.17	-0.19	-0.12	-0.46*	0.45*

Figure 1. Schematic Overview of the Affect Heuristic Model. This figure presents a schematic overview of different predictions made by standard finance and the affect heuristic, respectively. Panel A and B show how positive (negative) affect caused by low (high) return increases (decreases) perception of risk. Panel C and D represent the inferences made in standard finance based on equilibrium models such as the capital asset pricing model (CAPM). This figure shows that the two predict exactly the opposite effect on risk (perception).



$$Pay-off = \begin{cases} €10 - €5 = €5 \\ €0 - €5 = -€5 \end{cases}$$

$$\Delta = \frac{0-5}{10-0} = -0.5$$

$$Cash = \begin{cases} 0 - -5 = 5 \\ 5 - 0 = 5 \end{cases}$$

Figure 2. The Put Option on the Lottery Replicated. This figure presents a schematic overview of the replication-strategy underlying the reasoning of the insurance expert in determining the lottery insurance price as a put option. The pay-off of the lottery is obtained by subtracting the €5 fee subjects paid for entering in the lottery from total earnings in each of the two possible states of the world. Since the lottery insurance protects against losses in the lottery, the insurance should pay €5 contingent on losing the lottery and €0 contingent on winning it. Because the put option pay-offs can be replicated by holding -0.5 the lottery and adding €5 in cash, the price of the option has to equal: €5 * (-0.5) + €5 = €2.50.

Figure 3. Schematic Overview of the Experiment. The figure shows an overview of the sequence of events in the experiment. In round 0, subjects were allowed to read the general instructions convening information regarding the procedures during the experiment and payment. In the first round subjects selected their lottery ticket, which determines whether they won or lost the lottery. In round 2 subjects had to report information regarding their emotional state and provide a risk assessment of the lottery. Round 3 consists of the option pricing task, while round 4 consists of a financial literacy test and some additional questions regarding the individual's investment style.

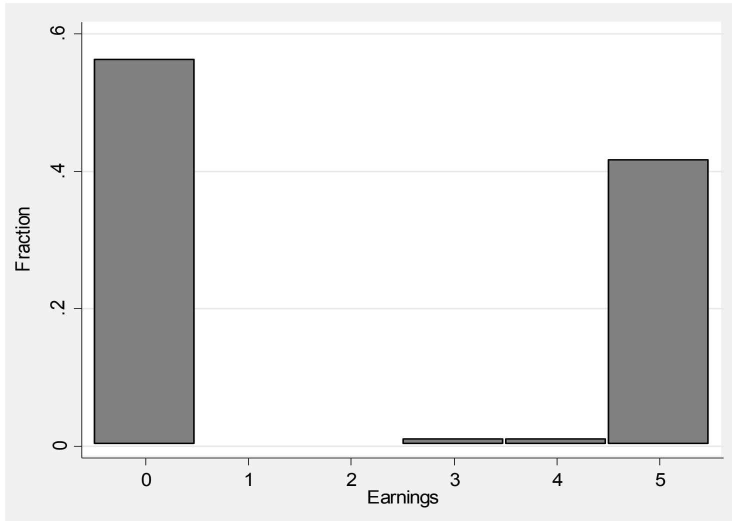


Figure 4. Distribution of Option Pricing Earnings. This figure shows the distribution of subject earnings in estimating the option price quote provided by the insurance expert. Most subjects gave estimates outside the 245–255 eurocents range, and consequently did not earn anything. Of those who did earn money, most provided the correct answer. Out of 95 quotes only 2 earned amounts were different from €5 or €0.

Appendix A: Instructions and questionnaires

(---Text provided before the start of round 1---)

General instructions
Welcome to this experiment which consists of several rounds. In each round you will be asked to perform an individual task or fill out a questionnaire. By participating in the experiment you earn €10. You may win extra money, but you might also lose money – partly based on your own performance.

It is important not to talk to other participants at any time during this experiment, unless you are asked a specific question by one of the instructors. If you do talk to other participants you will not receive the €10 participation fee and you will also be dismissed from further participation. In addition, please switch off your mobile phone. If you have any questions about the instructions of this experiment, please put your hand up and one of the instructors will come to help you.

The envelope lottery
In this experiment you will enter into a lottery for which €5 is deducted from your initial endowment as payment for a lottery ticket. The lottery tickets are in the envelopes in a plastic box at the front of this room. The envelopes contain the lottery tickets which determine whether a player wins or loses the lottery. Winners in the lottery receive their entrance fee of €5 back, in addition to an extra €5 in winnings. Losers in the lottery receive nothing causing a total loss of €5. In the box containing the tickets there are the same number of envelopes containing winning tickets as losing tickets. You may choose an envelope yourself, so we as organizers have no influence on who wins and who loses. Note that participation in the lottery is mandatory, so you have to draw an envelope in exchange for €5 out of your participation fee.

Procedure
This experiment is conducted in 4 rounds. In each round you will be asked to select and open an envelope. After you and all the other participants have selected an envelope from a plastic box, one of the instructors will signal that you may open it. In the first round you will participate in the lottery. On the top right of the lottery ticket you will find your subject number, which is not linked to your name. Working with a subject number guarantees that your decisions and answers to questionnaires remain anonymous. Consequently, your privacy is guaranteed! Please keep your lottery ticket with you during the whole experiment so you can easily write your subject number on the forms in the subsequent rounds. Your lottery ticket also allows us to pay you at the end of the experiment.

Further instructions on the tasks you will be asked to perform will be provided in each round. Furthermore, you should pay close attention to verbal instructions given to you by the instructors between rounds.

Payment
Your total earnings will be paid to you exactly one week after today on Wednesday the 13th of February. The total amount you will receive consists of your €10 participation fee, corrected for the result in the lottery, +/- €5 and possible increased by your earnings in round 3, based on your performance.

Further instructions
If anything is unclear, please put up your hand so the instructors can answer your questions now. During the experiment there will be no opportunities to ask questions. Always provide answers according to your

own interpretation of the questions. The experiment will start in a few minutes on the signal of one of the instructors.

(---A lottery ticket received by a subject who lost the entrance fee in round 1---)

YOU **LOST** THE LOTTERY

THIS MEANS YOU HAVE LOST OUT OF YOUR ENDOWMENT

€ 5,-

BETTER LUCK NEXT TIME

(---Self-reported emotion and risk perception questionnaire used in round 2---)

Instructions
Below you will be asked to answer several questions about the emotions you are currently experiencing, your mood, your energy level, and the risk associated with the lottery in this experiment. Please answer by circling the most appropriate answer to the question.

Emotions
In the table below you will find the names of 16 emotions in alphabetical order. A 7-point intensity scale allows you to indicate how intensely you are currently experiencing an emotion. If you are not experiencing a specific emotion please circle the 1. If you experience an emotion very intensely please circle the 7. All numbers in between indicate intermediate intensity levels.

admiration	I am not experiencing this emotion at the moment	1	2	3	4	5	6	7	I currently experience this emotion very intensely
anger		1	2	3	4	5	6	7	
anxiety		1	2	3	4	5	6	7	
contempt		1	2	3	4	5	6	7	
disappointment		1	2	3	4	5	6	7	
envy		1	2	3	4	5	6	7	
fear		1	2	3	4	5	6	7	
gratitude		1	2	3	4	5	6	7	
guilt		1	2	3	4	5	6	7	
Irritation		1	2	3	4	5	6	7	
joy		1	2	3	4	5	6	7	
pride		1	2	3	4	5	6	7	
regret		1	2	3	4	5	6	7	
sadness		1	2	3	4	5	6	7	
shame		1	2	3	4	5	6	7	
surprise		1	2	3	4	5	6	7	

Mood

On the scale below, how would you describe your current mood? Indicate a good mood by circling 1 on the scale below and a very bad mood by circling the 7. Use the numbers between 1 and 7 to indicate intermediate levels.

good mood	1	2	3	4	5	6	7	bad mood

Energy level

Please indicate your current energy level on the 7-point scale below. If you have lots of energy, please circle the 1. If you are feeling very fatigued, please circle the 7. All intermediate levels can be indicated by the numbers 2 to 6.

lots of energy	1	2	3	4	5	6	7	very fatigued

Lottery riskiness
Please indicate how risky you feel the lottery was that you played. If you believe the lottery was riskless, then circle the 1 on the 7-point scale below. If you believe the lottery to be very risky, circle the 7. Again you can also indicate intermediate levels of riskiness by circling the numbers 2 to 6.

no risk	1	2	3	4	5	6	7	very risky

Further instructions
You have now finished round 2 of the experiment. Make sure you have answered all questions and wrote down your subject number on all forms! When you are finished, please put back the forms into the envelope for round 2 and wait for the envelope to be retrieved by one of the instructors.

(---Instructions for the insurance valuation task used in round 3 ---)

Lottery insurance
The organizer of the lottery wants to introduce insurance for players in the lottery. After paying the insurance premium, players who draw a losing envelope will not lose €5 out of their endowment they paid for entering into the lottery. Drawing a winning number still results in payment of the €5 prize.

An insurance expert has been hired to calculate the premium for the insurance. He has indicated that the price for insurance in the lottery can objectively be determined. In a footnote the expert remarked that he priced the insurance as if both the lottery and insurance can be traded and combined as freely as financial securities such as bonds, stocks and currencies.

Pricing task performance fee
You can earn money in this round of the experiment by estimating the insurance premium the insurance expert quoted as precisely as possible. If your estimate is exactly the same as the quote by the insurance expert, you will receive €5 in addition to your other earnings. The minimum payoff for this task is €0, so you cannot lose money by incorrectly estimating the premium. For every cent you deviate from the insurance experts' quote, €1 will be deducted from your maximum earnings in this task. In the table below you will see the payoff for different deviations from the quote.

Deviation from insurance price in cents	*-5 and more*	*-4*	*-3*	*- 2*	*- 1*	*+/- 0*	*+ 1*	*+2*	*+3*	*+4*	*+5 and more*
Valuation payoff in €	*0*	*1*	*2*	*3*	*4*	*5*	*4*	*3*	*2*	*1*	*0*

Your estimate

Indicate as precisely as possible what you think the insurance expert quotes as the lottery insurance premium.

The premium for this insurance is:______

Further instructions
You have now finished round 3 of the experiment. Make sure you have written down your subject number on this form! When you are finished, please put back this form into the envelope for round 3 and wait for the envelope to be retrieved by one of the instructors.

(---Final questionnaire for round 4---)

Instructions
In this final envelope you are asked several general questions. The first part comprises of some general background information. The second part tests your knowledge of financial concepts. The final part addresses your personal preferences.

General information
This part of the questionnaire comprises some general questions about you.

Question 1
My age is______

Question 2
My Gender
male [ ]
female [ ]

Question 3
Highest level of education:
Primary education [ ]
High school [ ]
Bachelor [ ]
Master [ ]
PhD [ ]

Question 4
Have you ever participated in an economics experiment before?
Yes [ ]
No [ ]

Financial concepts
In this part of the questionnaire is about financial concepts.

1) Suppose you had €100 in a savings account and the interest is 2% per year. After 5 years, how much do you think you would have in the account if you left your money to grow?
   a) More than €102
   b) Exactly €102
   c) Less than €102

d) Do not know

2) Suppose you had €100 in a savings account and the interest rate is 20% per year and you never withdraw any money or interest payments. After 5 years, how much would you have in total?
   a) More than €200
   b) Exactly €200
   c) Less than €200
   d) Do not know

3) Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account?
   a) More than today
   b) Exactly the same
   c) Less than today
   d) Do not know

4) Assume a friend inherits €10.000 today and his sibling inherits €10.000, 3 years from now. Who is richer because of the inheritance?
   a) My friend
   b) His sibling
   c) They are equally rich
   d) Do not know

5) Suppose that in the year 2014, your income has doubled and prices of all goods have doubled too. In 2014 how much will you be able to buy with your income?
   a) More than today
   b) The same
   c) Less than today
   d) Do not know

6) Suppose that you can buy and sell financial products, without any lending restrictions. Consider two of such assets labelled A and B, both promising a risk free €100 in one year time. Suppose the price of investment A to be €98. What should the price of investment B be?
   a) The price of investment B should be higher than that of investment A
   b) The price of investment B should be the same as that of investment A
   c) The price of investment B should be lower than that of investment A
   d) Do not know

7) Two banks labelled Alpha and Beta offer loans and savings deposits. Bank Alpha offers both their loans and savings deposits against a 5% interest rate, while Bank Beta offers both loans and savings deposits against a 4% interest rate. Deposits are guaranteed, so they are completely riskless. With which strategy can earn you money
   a) Take out a loan for €100 at bank Alpha and deposit the €100 at bank Alpha
   b) Take out a loan for €100 at bank Beta and deposit the €100 at bank Alpha
   c) Take out a loan for €100 at bank Beta and deposit the €100 at bank Beta

d) Do not know

8) Which of the following statements about a buyer of a put option on a stock is correct?
   a) A The Buyer of a put option has the obligations to buy the underlying stock at maturity
   b) A The Buyer of a put option has the right but not the obligation to sell the underlying stock at maturity
   c) A The Buyer of a put option has the right but not the obligation to buy the underlying stock at maturity
   d) Do not know

9) Suppose that an investor can buy and sell a stock and a put option on this stock. With which strategy can you lose the highest amount of money?
   a) Sell only the stock
   b) Sell only the put option
   c) Buy only the stock
   d) Buy only the put option
   e) Do not know

10) Suppose you have divided €100 in savings equally between stocks and your savings account. How can you make sure that the initial € 100 will never drop below €80 in case the stock decreases in value?
   a) Buy some extra stocks
   b) Do not buy or sell stocks
   c) Sell some of your stocks
   d) Do not know

Personal preferences

Below you will be asked some questions about your personal preferences. Your answers reflect personal tastes and consequently your answers cannot be correct or incorrect.

Question 1: saver or investor

If you had to qualify yourself as either more of a saver or an investor on the 7-point scale below, which number would describe you best?

Saver	1	2	3	4	5	6	7	Investor

Question 2: willingness-to-pay

Consider the lottery insurance you were asked about once more. Earlier, we wanted you to estimate what an the insurance expert calculated as objective premium. Now we ask you what you would be willing to pay for the insurance protecting against the loss off €5, regardless of the premium the insurance expert calculated.

The premium I would be willing to pay for the insurance on the lottery is:______ cents.

Further instructions

You have now finished the final round of this experiment. Make sure you have answered all questions and wrote down your subject number on all forms! When you are finished, please put back the forms into the envelope for round 4 and wait for the envelope to be collected by one of the instructors. When all envelopes have been collected the experiment is over.

Appendix B: Photos of the experiment





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