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Sadder but wiser: The Effects of Affective States and Weather on Ambiguity Attitudes

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The effects of affective states and weather on ambiguity attitudes

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Abstract

Many important decisions are made without precise information about the probabilities of the outcomes. In such situations, individual ambiguity attitudes influence decision making. The present study identifies affective states as a transient cause of ambiguity attitudes. We conducted two random-assignment, incentive-compatible laboratory experiments, varying subjects' affective states. We find that sadness induces choices that are closer to ambiguity-neutral attitudes compared with the joy, fear, and control groups, where decision makers deviate more from payoff-maximizing behaviors and are more susceptible to likelihood insensitivity. We also find a similar pattern in a representative population sample where cloudy weather conditions on the day of the survey - a proxy for sad affect - correlate with more ambiguity-neutral attitudes. Our results may help explain real-world phenomena such as financial markets that react to regular fluctuations in weather conditions.

***Keywords*:** Ambiguity attitude; affect; joy; fear; sadness; weather; experiment.

***JEL Codes*:** D03, D81

1 Introduction

A myriad of decision situations in the domains of both professional and private life involve incomplete or entirely absent information about the likelihood of decision outcomes. For example, novel technological developments or changing environmental framework conditions prohibit the extrapolation of past experiences and data to guide decision making (Knight 1921). Financial investments in publicly traded assets are also characterized by ambiguity because the future performance of assets can be influenced by external shocks with unforeseen consequences.

Such ambiguity, i.e., the absence of precise, probabilistic information about decision outcomes, can influence decision making in ways that are not well explained by subjective expected utility (Savage 1954) if the preferences of people are sensitive to the availability of information (Ellsberg 1961). Importantly, ambiguity attitudes, i.e., the sensitivity of decision making to the availability of probabilistic information about the outcomes, are not identical to risk attitudes. Following Knight (1921), one can distinguish risk, where objective probabilities are available, from uncertainty or ambiguity, where they are not. In fact, several studies have shown that risk and ambiguity attitudes are only weakly correlated with each other, if at all (e.g., Agnew et al. 2008, Borghans et al. 2009). Furthermore, decisions under risk and ambiguity seem to engage partially separate neural systems (Huettel et al. 2006). For example, the relevance of ambiguity attitudes has been demonstrated in macroeconomics (Hansen and Sargent 2007), finance (Bossaerts et al. 2009, Dimmock et al. 2013, Dow and Werlang 1992), and strategic management (Amit and Schoemaker 1993, Barney 1991).

Individual attitudes toward ambiguity do not only involve subjective beliefs about possible decision outcomes but also reflect different degrees of confidence that people have in their own beliefs (Ellsberg 1961, p.657). Thus, decision making under ambiguity is influenced by personal judgments and confidence, which may be influenced by affective states in an affect-congruent manner (Bower 1981, Forgas 1995, Schwarz and Clore 1983). These subjective aspects may lead to temporary fluctuations of ambiguity attitudes that could induce "noisy" decision making, i.e., non-identical decisions of the same person in the same situation over time (Schelling 1984). If the ambiguity attitudes of many decision makers are simultaneously influenced by the same affective stimuli, self-reinforcing dynamics with far-reaching consequences could result, such as financial bubbles due to herding effects (Devenow and Welch 1996, Nofsinger and Sias 1999). Thus, a better understanding of the causes of individual fluctuations in ambiguity attitudes may help decision makers avoid the negative consequences arising from unstable preferences (Schelling 1984) and also help explain why financial markets react to irrelevant information such as regular fluctuations in weather (Cao and Wei 2005, Hirshleifer and Shumway 2003, Saunders 1993) and daylight (Kamstra et al. 2003) or the results of major sport competitions (Edmans et al. 2007).

Experimental research designs are typically required to precisely quantify and understand the causal effect of affective states on behavior. The role of affect on risk preferences has been experimentally studied both in psychology (e.g., Hockey et al. 2000, Isen and Patrick 1983, Johnson and Tversky 1983, Lerner and Keltner 2001, Yuen and Lee 2003) and in behavioral economics (e.g., Hirshleifer and Shumway 2003, Kamstra et al. 2000, 2003, Kliger and Levy 2003, Yuan et al. 2006). However, to the best of our knowledge, no experimental studies have been conducted so far on the impact of affective states on ambiguity attitudes. Our study attempts to fill this void.

Our paper presents the first set of studies directly testing the causal impact of affective states and weather on ambiguity attitudes. In two random-assignment, incentive-compatible laboratory experiments (Study 1 and Study 2) involving more than 500 subjects overall, we induced subjects with joyful, fearful, sad, and neutral affects in a between-subjects design by showing them short video clips prior to measuring ambiguity attitudes. In these experiments, we measured subjects' willingness to bet on ambiguous events through probability equivalents. We elicited objective probabilities such that subjects were indifferent between winning a given money amount if some ambiguous events occurred and winning the same amount with these objective probabilities. The probability equivalents were used as indicators of ambiguity attitudes.

In addition to these two experiments, we also studied whether our laboratory evidence is consistent with naturally occurring data (Study 3). To do so, we investigated the impact of weather, a typical proxy for affect (e.g., Hirshleifer and Shumway 2003, Kamstra et al. 2000, 2003, Kliger and Levy 2003, Saunders 1993), on ambiguity attitudes in a representative sample of the Dutch population (Dimmock et al. 2013).

2. Related literature

2.1 Ambiguity attitudes

Keynes (1921) noted that the ratio of evidence in favor and against an event matters for decision makers (determining its probability) in addition to the total amount of evidence available. Nonetheless, the traditional method of studying ambiguity was to use Savage's (1954) subjective expected utility model because risk was studied using von Neumann and Morgenstern's (1944) expected utility. The only difference between these models is that probabilities are subjective in the former and objective in the latter. In such an approach, people's behavior is assumed to be the same without regard to whether the probabilities are objective.

However, Ellsberg (1961) proposed a thought experiment that raised doubts about the descriptive validity of such an assumption. When people can choose which color they bet on (red or black) and then can choose between the known urn (50 red, 50 black balls) and the ambiguous urn (unknown proportion of the two colors), preferring the known urn cannot be explained by a model such as subjective expected utility nor by any probabilistically sophisticated models (Machina and Schmeidler 1992), i.e., models assuming similar behaviors for objective and subjective probabilities but relaxing the expected utility hypothesis. Many models have been proposed to accommodate ambiguity attitudes, from Gilboa and Schmeidler's (1989) maxmin expected utility to Klibanoff et al.'s (2005) smooth ambiguity models or Hansen and Sargent's (2001) multiplier preferences.

Ellsberg's paradox for expected utility has been confirmed in many experiments (Camerer and Weber 1992), highlighting the importance of ambiguity aversion as a behavioral pattern. However, ambiguity does not only generate aversion but may also decrease the ability of decision makers to discriminate between likelihood levels. The more ambiguity, the more decision makers behave as if their beliefs were close to 50-50. Sometimes called ambiguity-generated insensitivity, this phenomenon has been highlighted in several experimental studies (Abdellaoui et al. 2011, Kilka and Weber 2001, Maafi 2011). When comparing ambiguity attitudes at various likelihood levels, ambiguity-generated insensitivity leads to more ambiguity aversion for high-likelihood levels than for low ones, for which people might even be ambiguity seeking (Hogarth and Einhorn 1990).

2.2 Affect, information processing, and ambiguity attitudes

Insights from psychology about how affect influences information processing may help understand how it can impact choices under ambiguity. While negative affect is typically associated with more systematic and analytic forms of processing (e.g., Schwarz and Clore 1996), positive affect appears to promote intuitive and holistic information processing (e.g., Isen 1999, 2000, 2004).

The distinction between positive and negative affect is common in the literature. By looking at "positive" versus "negative" or "neutral" affects, many studies treat affect as a unidimensional and bipolar construct (Clore et al. 1994, Forgas 1995, Schwarz 1990). Implicit in these comparisons is the assumption that all positive or all negative affective states are essentially equivalent. Under this assumption, fear and sadness would be expected to have similar effects. Both fear and sadness would lead to increased processing motivation (Schwarz 1990), a tendency to engage in a detail-oriented and systematic step-by-step analysis of the information at hand (Mackie and Worth 1989), low distractibility and a sustained analysis of problem material (Andrews and Thomson 2009). Likewise, positive affect such as joy would lead to reduced processing motivation (Schwarz 1990), greater reliance on heuristics and general knowledge structures (Ruder and Bless 2003), the activation of more widespread associative networks (Ashby et al. 1999), and increased distraction (Dreisbach and Goschke 2004).

Some recent investigations (Lerner and Keltner 2000, 2001, Ranguthan and Pham 1999) have highlighted the importance of examining more discrete affective states, showing that discrete negative affective states such as anger and fear differentially impact judgment and decision-making outcomes because different positive affective states (e.g., pride versus cheerfulness) or different negative affective states (e.g., anger versus sadness) may have different circumplex structures (e.g., Russell 1980, Watson and Tellegen 1985), different informative values (e.g., Pham 1998, Schwarz 1990), and different cognitive determinants (e.g., Lazarus 2001, Roseman and Smith 2001).

In this study, we look at two negative affective states, fear and sadness, because negative affects have demonstrated more mixed results than different positive affective states on decision making (Isen 1999, 2000, Schwarz et al. 1991). In addition, negative affective states and their effects on decision outcomes are more differentiated than positive affective states (e.g., Ellsworth and Smith 1988). Finally, we focus on fear and sadness because they are among the most widespread forms of emotional distress and are thus likely to be of economic relevance (Ekman 1992, Scherer 2005). Within this perspective of discrete affective states, we seek to investigate the unique consequences of joy, fear, and sadness on ambiguity attitudes.

We investigate whether fear and sadness have similar effects, i.e., enhanced information processing, and whether joy results in reduced information processing. If so, enhanced information processing would lead to "wiser" decisions, namely ambiguity-neutral choices, compared with reduced information processing, which may bias individuals' ambiguity attitudes.

3. Study 1

3.1 Method

3.1.1 Subjects

We conducted Study 1 with 322 subjects in a German university's laboratory for economic experiments in summer 2011. The participants were recruited using the Internet-based ORSEE system (Greiner 2004). Our sample consisted of 148 males and 174 females with an average age of 24 years (*SE* = 0.24). The youngest and oldest subjects were 18 and 61 years old. In total, 315 of the subjects were undergraduate students from various fields, and 7 were non-students.

3.1.2 Affect induction procedure and control group

At the beginning of the experiment, the subjects were randomly allocated to one of four treatment groups and signed consent forms confirming that they had read and understood the terms and conditions of the experiment and that the experimenters answered all of their questions sufficiently. The consent form also stated that the subjects could leave the experiment at any time, and in such a case, they would only receive their participation fee. The rest of the experiment was computerized, using z-tree (Fischbacher 2007).

Before responding to the decision tasks, three of the groups were induced into either a joyful, fearful, or sad affective state using standardized film clips that were seven minutes long (Gerrards-Hesse et al. 1994, Hewig et al. 2005, Westermann et al. 1996). Using film clips to manipulate affect is a standard method in psychological research (e.g., Heilmann et al. 2010, Lee and Andrade 2011, Lerner et al. 2004, Papousek et al. 2009). Film clips have been shown to be one of the most effective manipulations for positive *and* negative affective states (Gerrards-Hesse et al. 1994, Westermann et al. 1996). We used a joyful film clip from "When Harry met Sally" (1989), a fearful film clip from "Paranormal Activity" (2007), and a sad film clip from "The Champ" (1979) (more details about the films are provided in Appendix A). Before watching the film clip, the subjects were asked to clear their mind of all thoughts, feelings, and memories. Affect induction has been shown to be more intense when explicit instructions are given (Westermann et al. 1996). One-quarter of the subjects served as the control group and did not receive any affect induction. This group is most comparable to standard experiments on ambiguity preferences. At the end of the experiment, the subjects in the fear and sadness group watched the film clip from the joy treatment as a counter induction (Göritz and Moser 2006).

The subjects in the affected treatment groups were asked to fill out three subscales (joviality, fear, sadness) from the Positive And Negative Affect Schedule (PANAS-X, Watson and Clark 1994) before and after they watched the film clips. The control group answered these scales only once at the beginning of the experiment. We applied the joviality (e.g., happy, joyful, and delighted), fear (e.g., afraid, scared, and frightened), and sadness subscales (e.g., sad, blue, and downhearted) to assess individuals' affective states. On each subscale, the subjects were instructed to indicate whether an affect-related statement properly describes their current state, from 1 (not at all) to 5 (extremely).

3.1.3 Experimental tasks

We conducted two ambiguity tasks, one involving gains, the other involving losses. First, our subjects were given a gain task based on the traditional Ellsberg two-color problem. In this task, the subjects could win 800 experimental dollars (ED) if a red ball was drawn from one of two urns. The first urn (Urn 1) contained X red balls and (100 – X) black balls. The second urn (Urn 2) was ambiguous. It contained 100 balls, red or black, but the number of balls of each color was unknown. For all X from 0 to 90 with an increment of 10, the subjects were asked to report which urn they preferred. Table 1 displays the ten choices available to the subjects in the gain domain.

Table 1: The ten choices in the gain domain available to the subjects in Study 1

	Urn 1	Urn 2	Urn 1	Urn 2
1	Win 800 ED if a red ball is drawn from an urn with 0 red balls and 100 black balls.	Win 800 ED if a red ball is drawn from the ambiguous urn.	O	O
2	Win 800 ED if a red ball is drawn from an urn with 10 red balls and 90 black balls.	Win 800 ED if a red ball is drawn from the ambiguous urn.	O	O
3	Win 800 ED if a red ball is drawn from an urn with 20 red balls and 80 black balls.	Win 800 ED if a red ball is drawn from the ambiguous urn.	O	O
4	Win 800 ED if a red ball is drawn from an urn with 30 red balls and 70 black balls.	Win 800 ED if a red ball is drawn from the ambiguous urn.	O	O
5	Win 800 ED if a red ball is drawn from an urn with 40 red balls and 60 black balls.	Win 800 ED if a red ball is drawn from the ambiguous urn.	O	O
6	Win 800 ED if a red ball is drawn from an urn with 50 red balls and 50 black balls.	Win 800 ED if a red ball is drawn from the ambiguous urn.	O	O
7	Win 800 ED if a red ball is drawn from an urn with 60 red balls and 40 black balls.	Win 800 ED if a red ball is drawn from the ambiguous urn.	O	O
8	Win 800 ED if a red ball is drawn from an urn with 70 red balls and 30 black balls.	Win 800 ED if a red ball is drawn from the ambiguous urn.	O	O

9	Win 800 ED if a red ball is drawn from an urn with 80 red balls and 20 black balls.	Win 800 ED if a red ball is drawn from the ambiguous urn.	O	O
10	Win 800 ED if a red ball is drawn from an urn with 90 red balls and 10 black balls.	Win 800 ED if a red ball is drawn from the ambiguous urn.	O	O

For $X = 0$, the subjects were likely to prefer Urn 2, which might at least have some red balls. As X and thus the number of red balls increased, Urn 1 became more attractive. We define the *probability equivalent* of the subjects in this task as their switching point, i.e., the midpoint between the highest X for which subjects preferred Urn 2 and the lowest X for which they preferred Urn 1. This probability equivalent can be interpreted as the subjects' willingness to bet on the ambiguous event and is therefore a measure of their ambiguity attitude. Ambiguity neutrality corresponds to a probability equivalent of 50%. Thus, a probability equivalent of less than 50% indicates ambiguity aversion, and a probability equivalent of more than 50% indicates ambiguity seeking in this gain task.

The second ambiguity task was similar but with losses. In Table 1, "Win 800 ED" was replaced by "Lose 400 ED." In this task (and unlike the previous one), for $X = 0$, Urn 1 was more attractive because there was no risk of drawing a red ball and losing money. We define the probability equivalent in this loss task as the midpoint between the highest X for which subjects preferred Urn 1 and the lowest X for which they preferred Urn 2. The interpretation is reversed with respect to the gain task: a probability equivalent of less than 50% indicates ambiguity seeking (switching "early" to the ambiguous urn), and a probability equivalent of more than 50% indicates ambiguity aversion.

In addition to these two ambiguity tasks (the gain task and the loss task), the experiment consisted of two other decision tasks and several questionnaires measuring the subjects' affect and personality traits. Further details are provided in Appendix A.

3.1.4 Incentives

We varied the presence and magnitude of the financial incentives across subjects and within the four treatment groups. Overall, 142 subjects played with fixed financial stakes, 144 with low financial stakes and 36 with high financial stakes. The fixed-stakes treatment instructions indicated that, regardless of their performance, the subjects would receive a 9 EUR payoff at the end of the experiment. The subjects in the low- and high-stakes treatments were instructed that their payoff at the end of the experiment would depend on their decisions during the experiment. The subjects in the low-stakes treatment received an attendance fee of 4 EUR, and two randomly selected choices among the ten ambiguity task decisions was played for real money, with an exchange rate 100 ED equaling 1 EUR. Hence, potential losses would be covered by the initial endowment. The subjects in the low-stakes treatment therefore had the opportunity to earn up to 8 EUR more in the ambiguity tasks but also to lose their participation fee. The subjects in the high-stakes treatment received the same payoffs, but they also had a 1/36 (or 2.8%) chance for a higher exchange rate for the experimental dollars, which would become 1 ED = 1 EUR instead of 100 ED = 1 EUR. For these subjects, the loss question would not be played for real. After the experiment, one subject from the high-stakes treatment was randomly drawn and paid at the high exchange rate.

3.2 Results

The self-reported affects using the PANAS-X scales indicate that all of the affect inductions had the desired effect (see Appendix A). For the analysis of probability equivalents, we excluded 21 subjects for the gain task and 28 subjects for the loss task because they did not satisfy monotonicity, switching more than once between the urns or preferring first Urn 2 and then Urn 1 in the gain task, and first Urn 1 and then Urn 2 in the loss task. These subjects either had inconsistent ambiguity preferences or did not understand the tasks. A Chi^2 test gave no indication that the excluded subjects were non-randomly distributed across the experimental treatments for the gain task ($Chi^2 = 0.14$, $p = 0.99$) or for the loss task ($Chi^2 = 0.89$, $p = 0.98$).

We performed poolability tests (Chow 1960, Gujarati 1970) to examine whether the financial stakes treatments, the order of the experimental tasks, education, and gender had structurally different effects on the relationship between affect and ambiguity attitudes in the gain and the loss domains. The results indicate that only the order of the financial stakes treatments and the order of the experimental tasks show evidence against poolability. Therefore, we included these experimental conditions as control variables in the multivariate analyses reported below.[1] We apply analyses of covariances (ANCOVAs) instead of regressions because regression techniques only show the difference between a (arbitrary) reference group and the other groups instead of showing the full set of differences between all of the groups.

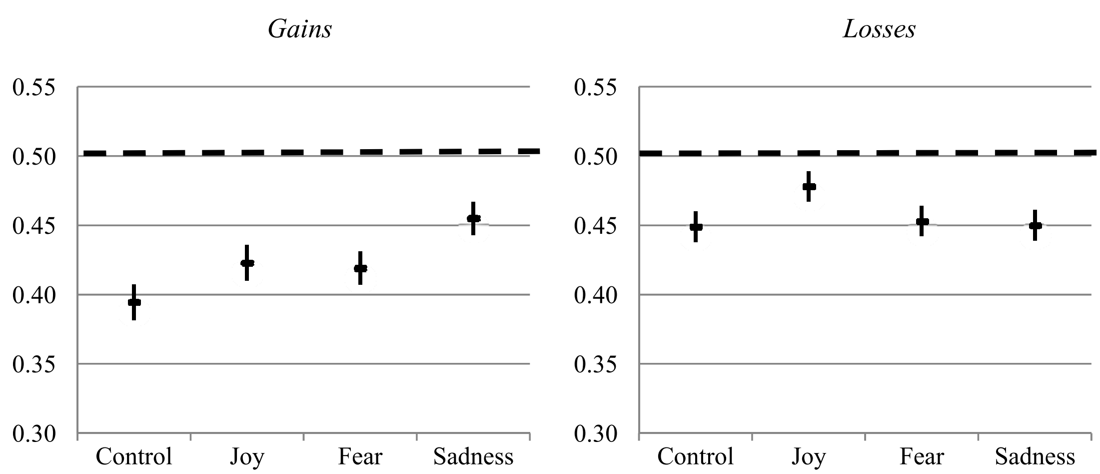

Figure 1: Probability equivalents for gains (left panel) and losses (right panel) in Study 1 (dots are averages, bars indicate standard errors, and dashed lines represent ambiguity neutrality)

Figure 1 represents the average probability equivalents displayed in Table 2. For both ambiguity tasks, we ran analyses of (co)variances (ANCOVA/ANOVA) to study the effects of the

[1] Detailed results of the poolability analyses are available upon request.

four treatment groups on the probability equivalents. In both the gain and the loss domains, the payoff-maximizing switching point was at 50%.

In the gain domain, we observe an average probability equivalent of 42%. Hence, on average, our subjects were ambiguity averse for this task. The control group deviates the furthest from purely payoff-maximizing preferences (39% probability equivalent), followed by the joy and fear groups (both 42%). The subjects in the sadness group were less ambiguity averse than the other groups. With an average probability equivalent of 46%, the subjects in the sadness group came close to the expected payoff-maximizing preferences. If we interpret the probability equivalents as the willingness to bet, the subjects in the sadness group were 18% (44% / 39% - 1 = 18%) more willing to bet on the ambiguous urn than the subjects in the control group.

Pairwise mean comparisons between the experimental groups, represented by Cohen's *d*s, standard errors of Cohen's *d*s, and significance levels in Table 2, reveal that the average probability equivalent of the sadness group was higher than that of the other groups, with *d*s ≥ 0.28.[2] Furthermore, when we include control variables, the average probability equivalent of the joy group was higher than that of the control group, with $d = 0.28$.

Table 2: Means (*M*) and standard errors (SE) from ANCOVA and pairwise comparisons of the probability equivalents across experimental groups in Study 1

	Statistic	***M***	***SE***	***N***	**Cohen's *d*s (SE of *d*s) and significance levels**		
	Experimental groups				**Control**	**Joy**	**Fear**
Gains	**Control**	0.39	0.01	74			
	Joy	0.42	0.01	75	0.21(0.17)/ 0.28(0.17)*		
	Fear	0.42	0.01	76	0.22(0.16)/ 0.24(0.17)	0.02(0.16)/ 0.04(0.16)	
	Sadness	0.46	0.01	76	0.56(0.17)***/ 0.55(0.17)***	0.35(0.17)**/ 0.29(0.16)*	0.34(0.16)**/ 0.33(0.16)**
Losses	**Control**	0.45	0.01	73			
	Joy	0.48	0.01	72	0.27(0.17)/ 0.31(0.17)**		
	Fear	0.45	0.01	75	0.05(0.17)/ 0.04(0.17)	0.21(0.17)/ 0.27(0.17)*	
	Sadness	0.45	0.01	74	0.01(0.16)/ 0.01(0.16)	0.27(0.17)/ 0.30(0.17)*	0.04(0.16)/ 0.03(0.16)

Notes: For both ambiguity tasks, we ran an ANOVA and then an ANCOVA (i.e., we added control variables) to study the effects of the four treatment groups on the probability equivalents. In the table, pairwise comparisons are represented by Cohen's ds (SE of ds), and the significance levels are based

[2] Cohen's *d* is an effect size for the comparison of two means, denoting the size of the standardized mean difference. Cohen (1988) suggests that $d = 0.20$ describes a small effect, $d = 0.50$ a medium effect, and $d = 0.80$ a large effect.

*on Fisher's least significant differences (LSD) post-hoc tests. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$. The first cell entry reports the ANOVA result, the second ANCOVA.*
Model diagnostics: Ambiguity attitudes for gains (N=301): ANOVA [$F(3, 297) = 4.22$, $p = 0.01$, partial $\eta^2 = 0.04$];[3] ANCOVA (controls: financial stakes treatments, order of the experimental tasks, age, gender): [$F(3, 291) = 4.19$, $p = 0.01$, partial $\eta^2 = 0.04$].
Ambiguity attitudes for losses (N=294): ANOVA: [$F(3, 290) = 1.12$, $p = 0.34$, partial $\eta^2 = 0.01$]; ANCOVA (controls: financial stakes treatments, order of the experimental tasks, age, gender): [$F(3, 284) = 1.63$, $p = 0.18$, partial $\eta^2 = 0.02$].

The interpretation for the loss domain is reversed with respect to the gain domain, and a probability equivalent below 50% describes ambiguity-seeking preferences for losses. Because we observe an average probability equivalent of 46%, our subjects were slightly ambiguity seeking in the loss domain, as is often found in the literature (Wakker 2010, p. 354). However, the subjects were overall less ambiguity seeking for losses than they were ambiguity averse for gains, as seen when comparing the left and right panels of Figure 1. We find differences (ds ≥ 0.21) between the joy group and the three other groups in the loss domain, and the subjects were less ambiguity seeking in the joy group.

3.3 Conclusion of Study 1 and introduction of Study 2

The results of Study 1 show that ambiguity attitudes can be influenced by randomly induced affective stimuli that are irrelevant for the decision tasks, such as watching a Hollywood film clip before making a financial decision. In particular, the subjects in the sadness group behaved more in line with ambiguity neutrality in the gain task than the subjects in the control, joy or fear groups. The results of Study 1 are suggestive, but the experimental design has some caveats that we attempt to address in Study 2. Both studies were conducted with different experimental pools, i.e., at different universities in different countries. Thus, Study 2 also serves as an independent replication of Study 1.

First, it was not possible to determine whether the results of Study 1 were driven by affect per se, by the effects of watching a film clip, or by the fact that the subjects who watched a film clip and subsequently answered the affect scales were made aware of their current affective state. To address these concerns in Study 2, we added two control groups: A control group who watched a film clip that induced a neutral mood, and a control group in which the subjects were asked to describe their current affective state (so as to be aware of their mood without watching a movie).

Second, a portion of the results of Study 1 could also come from an experimenter's demand effect because the subjects may have guessed the purpose of the experiment. In Study 2, we therefore asked the subjects to answer a few questions about the movie clip. When piloting the study with 50 students, we noticed that this simple manipulation prevented the subjects from discovering the real purpose of the experiment. Moreover, the subjects were told they would be paid for their correct

[3] *Partial eta squared* describes the proportion of variability associated with an effect when the variability associated with all other effects identified in the analysis has been removed from consideration (Fritz et al. 2012).

answers to the film questions to give them an incentive to concentrate when watching the film clips. Because we found the affect induction was effective, we decided not to apply the affect measures in Study 2[4] to make the purpose of the experiment less obvious.

Third, a portion of the ambiguity aversion we observed in the gain task in Study 1 could have come from subjects whose payoffs depended on the presence of red balls in the ambiguous urn; they may have suspected that the experimenters put few red balls in this urn. Of course, this concern would apply for all of the affect treatments as well as for the control group. Moreover, this concern is inconsistent with the result that the subjects were ambiguity seeking for the loss task, where, following the same reasoning, they should have assumed that there were many red balls in the ambiguous urn. Nevertheless, we avoided this problem in Study 2 by asking the subjects to bet on an event and on its complementary event, so that it would be clear that we could not manipulate their payoffs. In addition, we included extra questions to examine whether our results depended on the subjects' beliefs about those events.

Finally, the result from Study 1 that the subjects were less ambiguity averse in the sadness treatment in the gain domain did not tell us how sadness would affect situations in which people are ambiguity seeking in the gain domain, which typically occurs at low-likelihood levels. Hence, Study 2 varied the likelihood of winning in the ambiguous options.

4. Study 2

4.1 Method

4.1.1 Subjects

The second experiment was conducted with 241 undergraduates in the behavioral laboratory of a Dutch university in spring 2012. The participants were recruited using the Internet-based ORSEE system (Greiner 2004). The sample consisted of 141 male and 100 female students with an average age of 21 (*SE* = 0.15). The youngest and oldest subjects were 18 and 29 years old. All of the students were studying economics or economics-related subjects.

4.1.2 Affect induction procedures and control groups

Similar to Study 1, the experiment was programmed in z-tree (Fischbacher 2007). Six experimental groups were implemented in Study 2. The subjects in the sadness, joy, and fear groups watched the same film clips as in Study 1 and were informed beforehand that they would have to answer questions about it. As in Study 1, the subjects were asked to clear their mind of all thoughts, feelings, and memories before watching the film clip. After watching the clip, the subjects indicated whether they had seen the movie before and completed the ambiguity tasks described below. Immediately after the two ambiguity sections, we asked the subjects six questions to study subjects'

[4] Except for the control group, where we wanted the subjects to be aware of their current affect.

beliefs (please see Appendix B). Following the ambiguity tasks, the subjects answered five questions about the film clip, for which they received €0.50 per correct answer.

The three other experimental groups were control groups. Control Groups 1 and 2 watched a seven-minute clip from the movie "All the President's Men" (1976), which has previously been shown to induce a neutral affective state (Gross and Levenson 1995, Hewig et al. 2005). Control Group 1 watched the clip *after* the ambiguity tasks, making it comparable to the control group in Study 1, i.e., investigating the subjects' ambiguity attitudes when they were in a (positive) resting mood, without making their current mood salient to them (e.g., Clore and Huntsinger 2007, Schwarz and Clore 1983).

The subjects in Control Group 2 watched the neutral film clip *before* the ambiguity tasks (as in the sadness, joy, and fear groups). This control group allowed us to test whether watching a movie per se had an influence on ambiguity attitudes. The subjects in Control Groups 1 and 2 answered the five questions about the film clip after they had completed the ambiguity tasks.

Finally, the subjects in Control Group 3 did not watch a film clip but were made aware of their current affective state (Gasper 2004, Schwarz and Clore 1983). These subjects indicated their current affective state on three subscales (joviality, fear, sadness) of the PANAS-X (Watson and Clark 1994, Watson et al. 1988) and were subsequently asked to "please write a few sentences about why you feel like this at the moment on a separate piece of paper." After writing their explanations, the subjects completed the ambiguity tasks. In contrast to Study 1, the additional Control Groups 2 and 3 in Study 2 allowed us to disentangle the induced mood effects in the treatment groups from two potential confounds, i.e., watching a film clip and being aware of one's current affective state.

The subjects in all of the groups watched the same short film clip from "For the Birds" (Pixar 2001, three minutes) at the end of the experiment and answered five incentivized questions about the film afterwards. This procedure served three purposes. First, the subjects in the negative affect treatments watched this film clip as a counter induction (Göritz and Moser 2006). Second, this film clip helped to serve as a cover story to make the purpose of the study less evident to the subjects and thus reduce the demand effects that might artificially inflate the effect associated with the manipulations. Third, the subjects could win money by answering these film questions correctly in case they did not win money in the ambiguity tasks.

4.1.3 Ambiguity tasks

The second study used slightly modified ambiguity tasks compared with Study 1. We replaced ball colors with geometric figures to avoid colors that could impact the subjects' affect. Moreover, we varied the likelihood of winning by providing three types of geometric figures. The subjects were told that two urns contained 9 tickets each, and one geometric figure was represented on each ticket.

Urn A contained X triangles, Y squares, and $9 - X - Y$ rectangles. We varied X and Y across choices, from $X = 0$ to $X = 9$. Urn B also only contained triangles, squares, and rectangles, but in an unknown proportion. The subjects were given two tasks. In each task, they were asked to make a series of ten choices among the urns, with each choice corresponding to a value for X. In one task (the triangle task), they would win 20 EUR if a triangle was drawn from the urn they chose, and in the other task (the rectangle or square task), they would win the same amount if a rectangle or a square was picked from the urn. We randomized the order of these tasks across subjects. Table 3 represents the ten choices in each task.

Table 3: The ten choices subjects were asked to make in each task in Study 2

	Urn A	Urn B	Urn A	Urn B
1	□□□□▭▭▭▭▭	? ? ? ? ? ? ? ? ?	O	O
2	△□□□□▭▭▭▭	? ? ? ? ? ? ? ? ?	O	O
3	△△□□□▭▭▭▭	? ? ? ? ? ? ? ? ?	O	O
4	△△△□□□▭▭▭	? ? ? ? ? ? ? ? ?	O	O
5	△△△△□□▭▭▭	? ? ? ? ? ? ? ? ?	O	O
6	△△△△△□□▭▭	? ? ? ? ? ? ? ? ?	O	O
7	△△△△△△□▭▭	? ? ? ? ? ? ? ? ?	O	O
8	△△△△△△△□▭	? ? ? ? ? ? ? ? ?	O	O
9	△△△△△△△△▭	? ? ? ? ? ? ? ? ?	O	O
10	△△△△△△△△△	? ? ? ? ? ? ? ? ?	O	O

In the triangle task, Urn B was more attractive at the top of the table, but Urn A became more and more attractive the further down subjects went. In the square or rectangle task, the opposite was true. For both tasks, we explained this situation to the subjects so that they would be less likely to switch more than once between the urns and to facilitate monotonic decisions.

If triangles, squares, and rectangles are *exchangeable* in Urn B, i.e., if the subjects bet indifferently on any of these figures (Abdellaoui et al. 2011), we can compare a bet on one geometric figure in Urn B with a bet that gives a 1/3 chance to win. In the triangle task, an ambiguity-neutral subject should strictly prefer Urn A from the fourth row onward. If the subjects prefer Urn B for X but Urn A for $X + 1$ (X being the number of triangles in Urn A), we define their probability equivalent for triangles as $(X + 0.5)/9$. Switching to Urn A after the fourth row would indicate ambiguity seeking and lead to a probability equivalent higher than 1/3. The reasoning is reversed for the square or rectangle task. If the subjects prefer Urn A for X but Urn B for $X + 1$, we define their probability equivalent for triangles as $(8.5 - X)/9$. Switching to Urn B after the fifth row ($X = 4$) would give a probability equivalent lower than 2/3 and would indicate ambiguity aversion.

After the subjects completed the twenty choices, we asked them six questions to check whether their beliefs were compatible with exchangeability. The purpose of these questions was to test whether the subjects had reason to believe that there were more triangles or rectangles or squares in Urn B. This assumption was used to interpret the probability equivalents as indicators of ambiguity attitudes, and the beliefs of 151 subjects were in line with such reasoning. We used these observations as a robustness check in the following analysis.

4.1.4 Incentives

At the end of the experiment, socio-demographic information was collected, and one of the twenty choices in the ambiguity tasks was randomly selected by throwing a twenty-sided die. The subjects then drew a ticket from the urn they preferred and were paid accordingly. The payoff consisted of the participation fee (5 EUR), the payoff for the ambiguity tasks (0 EUR or 20 EUR), and the amount of correctly answered questions about the film (between 0 EUR and 5 EUR or between 0 EUR and 2.50 EUR for Control Group 3). The subjects were paid in cash and received their payoffs separately. The payoffs ranged between 6 EUR and 30 EUR.

4.2 Results

Ten subjects displayed choices that violated monotonicity, for instance, preferring the risky urn for a probability p of winning but preferring the ambiguous urn in spite of the risky urn becoming more attractive with a probability of winning that was higher than p. We excluded these subjects from the following analyses.

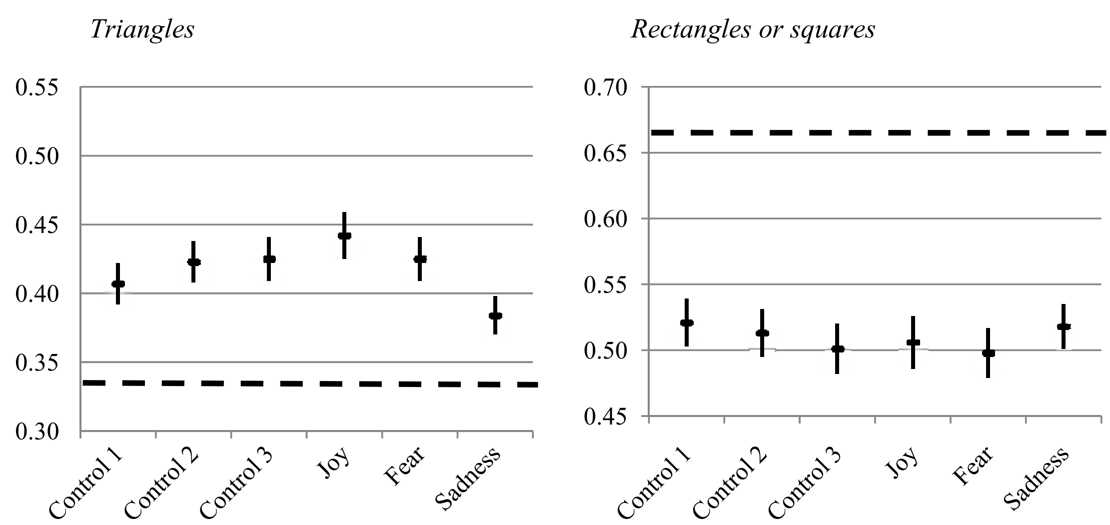

Figure 2: Probability equivalents for triangles (left panel) and rectangles or squares (right panel) in Study 2 (dots are averages, bars indicate standard errors, and dashed lines represent ambiguity neutrality)

Figure 2 shows the means and standard errors of the treatment groups for 1/3 (triangles) and 2/3 (rectangles or squares) probability of winning. Overall, the subjects were ambiguity seeking for triangles (probability equivalents higher than 1/3) but ambiguity averse for squares and rectangles (probability equivalent lower than 2/3).

We performed poolability tests (Chow 1960, Gujarati 1970) to examine whether the ordering of the ambiguity tasks, having seen the film before, education, gender, university, or employment status had structurally different effects on the relationship between affect and ambiguity attitudes. In the poolability tests, we found no evidence against poolability for most of these variables except the order of the ambiguity tasks and whether the subjects studied at the authors' home university or at another university (in the following, this variable is called *university*).[5] Therefore, we included *university* and the order of the tasks as control variables in the ANCOVAs reported below.

Table 4 displays the results of all of the pairwise comparisons from an ANOVA and two ANCOVAs with Cohen's *d*s, standard errors of Cohen's *d*s, and significance levels. The main finding is again that the subjects in the sadness group were less ambiguity seeking than the subjects in all of the other groups for the triangle task (1/3 probability equivalent of winning). We also ran the analysis for the subjects whose answers were consistent with exchangeability of triangles, rectangles, and squares. Our conclusions remain unchanged. It is worth noting that the mean probability equivalents for the triangle task were 38% for the sadness group and 44% for the joy and fear groups, which implies a difference in terms of willingness to bet of 16% (44% / 38% - 1 = 16%), showing that the effect is not only statistically noticeable but also economically relevant.

We did not find any effect of watching a movie per se, as indicated by the absence of differences between Control Group 2 (who watched a neutral movie clip before the ambiguity tasks) and Control Group 1 (who watched the neutral movie clip after the ambiguity tasks). The behavior of the subjects who were made aware of their current affective state by affect scales and self-reference statements (Control Group 3) did not differ from the behavior of the subjects in the other control groups. Hence, the effect of the sadness treatment does not seem to be explained by our subjects being distracted by a movie or by making them aware of their current affective state.[6]

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[5] Most of the subjects from another university were from a university of applied sciences in which the education is more practice-oriented. Detailed results of the poolability analyses are available upon request.

[6] As a side result, we found that the subjects of Control Group 3 ($N = 36$) were in a positive resting mood (Clore and Huntsinger 2007, Schwarz and Clore 1983). They were "moderately" joyful ($M = 3.15$, $SE = 0.14$) and had scores for fear and sadness between "not at all" and "a little" (fear: $M = 1.37$, $SE = 0.07$; sadness: $M = 1.54$, $SE = 0.12$).

Table 4: Means (*M*), standard errors (*SE*), and pairwise comparisons of the probability equivalents across experimental groups in Study 2

	Statistic	***M***	***SE***	***N***	**Cohen's *d*s (SE of *d*s) and significance levels**				
	Experimental groups				**Control 1**	**Control 2**	**Control 3**	**Joy**	**Fear**
Triangle	**Control 1**	0.41	0.02	40					
	Control 2	0.42	0.02	40	0.19(0.23)/ 0.17(0.23)/ 0.45(0.23)				
	Control 3	0.43	0.02	36	0.16(0.23)/ 0.19(0.23)/ 0.48(0.23)*	0.02(0.23)/ 0.02(0.23)/ 0.03(0.23)			
	Joy	0.44	0.02	31	0.38(0.23)/ 0.36(0.23)/ 0.44(0.23)	0.20(0.23)/ 0.20(0.23)/ 0.01(0.23)	0.22(0.22)/ 0.18(0.22)/ 0.04(0.22)		
	Fear	0.43	0.02	36	0.36(0.23)/ 0.18(0.23)/ 0.43(0.23)	0.17(0.23)/ 0.02(0.23)/ 0.02(0.23)	0.19(0.25)/ 0.00(0.25)/ 0.06(0.25)	0.03(0.22)/ 0.17(0.22)/ 0.01(0.22)	
	Sadness	0.38	0.01	49	0.22(0.24)/ 0.24(0.24)/ 0.05(0.24)	0.41(0.24)*/ 0.41(0.24)*/ 0.49(0.24)*	0.39(0.24)*/ 0.42(0.24)*/ 0.53(0.24)**	0.61(0.22)***/ 0.60(0.22)***/ 0.48(0.22)*	0.58(0.24)***/ 0.42(0.24)*/ 0.47(0.24)*
Square or rectangle	**Control 1**	0.52	0.02	40					
	Control 2	0.51	0.02	40	0.02(0.23)/ 0.07(0.23)/ 0.06(0.23)				
	Control 3	0.50	0.02	35	0.11(0.23)/ 0.17(0.24)/ 0.14(0.23)	0.09(0.23)/ 0.10(0.23)/ 0.08(0.23)			
	Joy	0.51	0.02	32	0.11(0.24)/ 0.14(0.24)/ 0.22(0.24)	0.09(0.24)/ 0.06(0.24)/ 0.28(0.24)	0.003(0.25)/ 0.04(0.25)/ 0.35(0.25)		
	Fear	0.50	0.02	37	0.03(0.23)/ 0.20(0.23)/ 0.00(0.23)	0.003(0.23)/ 0.13(0.23)/ 0.06(0.23)	0.09(0.24)/ 0.03(0.24)/ 0.14(0.24)	0.09(0.25)/ 0.07(0.25)/ 0.22(0.25)	
	Sadness	0.52	0.02	48	0.06(0.22)/ 0.03(0.22)/ 0.20(0.22)	0.04(0.22)/ 0.04(0.22)/ 0.14(0.22)	0.05(0.23)/ 0.15(0.23)/ 0.06(0.23)	0.05(0.23)/ 0.11(0.23)/ 0.42(0.23)	0.04(0.22)/ 0.17(0.22)/ 0.20(0.22)

*<u>Notes</u>: Per cell, we report the results of an ANOVA and two ANCOVAS (the second ANCOVAs are restricted to subjects whose beliefs satisfy exchangeability) to study the effects of the six treatment groups on ambiguity attitudes. In the table, pairwise comparisons are represented by Cohen's ds (SE of ds), and the significance levels are based on Fisher's least significant differences (LSD) post-hoc tests. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.*
<u>Model diagnostics</u>: Triangle task (N = 231): ANOVA: [F (5, 226) = 2.14, p = 0.06]; ANCOVA (controls: order of the experimental tasks, university, employment status): [F (5, 217) = 1.69, p = 0.14]; ANCOVA with same controls restricted to subjects satisfying exchangeability: [F (5, 133) = 1.62, p = 0.16]. Effect size for experimental groups across all analyses: partial η^2 = 0.04.
Square or rectangle task (N = 231): [ANOVA: F (5, 226) = 0.09, p = 0.99]; ANCOVA (controls: order of the experimental tasks, university, employment status): [F (5, 217) = 0.26, p = 0.93]; ANCOVA with same controls restricted to subjects satisfying exchangeability: [F (5, 133) = 0.64, p = 0.67]. Effect size for experimental groups across all analyses: partial η^2 = 0.01.

4.3 Conclusion of Study 2 and introduction of Study 3

Study 2 confirms that affective states can impact ambiguity attitudes. In particular, sadness reduced the deviations from rational behavior (understood as payoff or expected utility maximization). Only one of the two tasks was influenced, but the effect of sadness in both tasks pointed in the same direction, i.e., weaker deviations from ambiguity neutrality.

Despite their advantages in isolating causal effects, laboratory experiments such as those we conducted for Studies 1 and 2 are sometimes criticized because their student subject pools are not representative of the population, the sample sizes are relatively small, and the decision situations are unnatural (Falk and Heckmann 2009). One possibility to address such concerns is to complement evidence from the laboratory with naturally occurring data from large, representative population surveys (Rosenzweig and Wolpin 2000). Such additional evidence would help to test the external validity of laboratory results. Study 3 reports such evidence and also allows us to link our results to the related literature that found effects of weather on financial markets (Cao and Wei 2005, Hirshleifer and Shumway 2003, Kamstra et al. 2003, Saunders 1993).

5. Study 3

5.1 Data on ambiguity attitudes

We conducted Study 3 using data from the Dutch Longitudinal Internet Study for the Social Sciences (LISS 2013). LISS is a representative household survey conducted by CentERdata at Tilburg University among 5,000 households and 8,000 individuals based on a true probability sample of households drawn from the population register by Statistics Netherlands. In January 2010, a randomly selected set of 2,491 individuals in LISS was invited to participate in a survey on ambiguity attitudes, out of which 1,933 individuals responded (see Dimmock et al. 2013 for data details).

The respondents of the survey were presented with three tasks to measure their level of ambiguity. Each task elicited the probability equivalents of respondents for a likelihood level (either 10%, 50%, or 90%), using known and ambiguous urns. One of the tasks used two-color urns as we did in Study 1. For this "1 color out of 2" task, the probability equivalents can be compared to 50%, with lower values indicating ambiguity aversion (as in our gain task in Study 1). The two other tasks involved ten-color urns with the aim of varying the likelihood levels (as we did in Study 2). In one of these tasks, only one out of ten colors would allow the subjects to win 15 EUR. Probability equivalents lower (higher) than 10% would indicate ambiguity aversion (seeking). We will refer to this task as “1 color out of 10.” The third task involved 9 winning colors, which allows us to study ambiguity attitudes at high likelihood levels by comparing probability equivalents to 90%. We call this task “9 colors out of 10.”

For each of the three tasks, the subjects could first choose which would be the winning color(s). This procedure has two advantages. It reduces suspicion from the subjects, and it rules out alternative explanations of ambiguity aversion. For instance, in the “1 color out of 2” task, if the subjects who chose to bet on red have a probability equivalent of less than 50%, the result cannot be explained by the subjects thinking red is less likely than black. If they have such beliefs, they would choose to bet on black.

Probability equivalents were elicited using a bisection procedure (instead of choice lists as in Studies 1 and 2). This procedure relied on a series of binary choices between known and ambiguous urns. Within a given task, the ambiguous urn remained the same for all choices, while the known urn was adapted according to the respondent’s previous choices. The chance of winning with the known urn varied from the second round on, depending on the respondent's choice in the previous round (known or ambiguous). A task ended as soon as the respondent indicated to have no preference (indifference), or if the chance of winning fell below 2.5%. Each task consisted of six rounds at most.

Before completing the survey, half of the respondents were randomly assigned to a condition in which they were told that one of their choices would be played out for a possible real reward of 15 EUR, whereas the other half played for hypothetical rewards. In total, 510 respondents won a reward, for a total of 7,650 EUR paid in real incentives (Dimmock et al. 2013).

We matched the probability equivalents with background information in LISS about the respondents’ gender, educational attainment (coded as years of schooling), age, working status (currently working, “yes” or “no”), and current subjective satisfaction with their financial situation as control variables for our regression analyses. Not all of the background variables were available for every individual, reducing the final dataset to 1,550 observations. We further matched these data with weather information about the response day.

5.2 Weather data

As a proxy for the affective state of the respondents during the completion of the ambiguity survey, we used official weather data from the Royal Netherlands Meteorological Institute (KNMI 2013), exploiting the fact that LISS contains detailed information about when the respondents completed the ambiguity survey. Data collection for the ambiguity survey took place from January 4 - 27, 2010, and a summary of the weather during this time period is presented in Table 5. Temperatures of approximately 0 degrees Celsius, a short sunshine duration, and periods of rain and snow are typical winter weather conditions in the Netherlands.

Table 5: Average weather conditions per day in the Netherlands from January 4 - 27, 2010

	Mean	*SE*
Temperature (in 0.1 degrees Celsius)	-3.87	5.98
Sunshine duration (in 0.1 hours per day)	16.00	4.30
Precipitation duration (in 0.1 hours per day)	18.83	5.74
Average cloudiness per day (from 0 to 9)	6.60	0.35
Average mistiness per day (from 0 to 1)	0.09	0.03

Source: KNMI (2013) and authors' calculations, N = 24.

The advantage of using weather data as proxies for affect is that changes in the weather are reasonably random, exogenous events that can influence affect (Denissen et al. 2008, Keller et al. 2005, Kliger and Levy 2003, Parrot and Sabini 1990, Schwarz and Clore 1983, Sinclair et al. 1994), generating a natural experiment. Potential limitations include significant random variation across individuals of the effects of weather on affect and relatively small effects of weather on the overall variance in affective states (Denissen et al. 2008). However, for the purpose of hypothesis testing, these limitations can be mitigated by collecting a large enough sample that allows us to estimate small effect sizes precisely.

Specifically, we assume in this study that a longer sunshine duration and higher temperatures have a positive influence on affect in the winter, based on previous findings in the literature (Cunningham 1979, Keller et al. 2005, Kripke 1998, Leppämäki et al. 2002, 2003, Parrott and Sabini 1990, Schwarz and Clore 1983, Stain-Malmgren et al. 1998). Furthermore, we assume that cloudiness, mistiness and long periods of precipitation (i.e., a lack of sunshine) lead to sadness. The existing literature documents that seasonal conditions associated with a lack of sunshine (i.e., fall and winter) lead to an increase in depressive symptoms and seasonal affective disorder (Harmatz et al. 2000, Keller et al. 2005, Lurie et al. 2006, Molin et al. 1996, Rosenthal et al. 1984, Young et al. 1997).

The effect of specific weather conditions may vary across seasons and regions (Keller et al. 2005). For example, both sunshine and high temperature have been associated with positive affective states (Cunningham 1979, Keller et al. 2005) in moderate climate zones. However, sunshine tends to co-occur with lower temperatures in January in the Netherlands (see Table 6), which may bias the effects of these variables if they would be considered separately.

Table 6: Correlations of weather variables

		T	*S*	*P*	*C*
Temperature (in 0.1 degrees Celsius)	***T***	-			
Sunshine duration (in 0.1 hours per day)	***S***	-0.34*	-		
Precipitation duration (in 0.1 hours per day)	***P***	0.13	-0.35*	-	
Average cloudiness per day (from 0 to 9)	***C***	0.59***	-0.78***	0.33	-
Average mistiness per day (from 0 to 1)	***M***	0.27	0.24	-0.29	0.03

*Source: KNMI (2013) and authors' calculations, N = 24, Pearson correlations are two-tailed * p < 0.10, ** p < 0.05, and *** p < 0.01.*

5.3 Results

Table 7 classifies the respondents according to their ambiguity attitudes by comparing their probability equivalents for each task with the respective ambiguity neutrality threshold (10% in the "1 color out of 10" task, 50% in the "1 color out of 2" task, and 90% in the "9 colors out of 10 task"). Consistent with the related literature and with our results from Studies 1 and 2, the respondents in this survey showed a tendency towards ambiguity seeking for low-likelihood events, whereas they tended towards ambiguity aversion for moderate- and high-likelihood events.

Table 7: Frequency distribution of the respondents (N = 1,550) with ambiguity-averse, ambiguity-neutral and ambiguity-seeking attitudes

	1 color out of 10	**1 color out of 2**	**9 colors out of 10**
Ambiguity averse	29.6%	62.8%	47.2%
Ambiguity neutral	23.2%	16.1%	19.2%
Ambiguity seeking	47.3%	21.2%	33.6%

In the regression analyses below, we considered the available weather variables jointly to avoid biases resulting from the correlation structure of the weather variables (Table 6). We conducted various robustness checks by piecewise exclusion of these variables as well as by adding additional weather variables (rain, snow, ice formation) to the estimated model (see Appendix C, Tables C1-C2). Our main results are qualitatively robust to these changes. Furthermore, we also estimated Tobit instead of Ordinary Least Squares regressions and find qualitatively identical results. Table 8 presents the results of our regression model. The results show that cloudiness is associated with higher probability equivalents for events with moderate and high likelihood ("1 color out of 2" and "9 colors out of 10"). Hence, cloudiness is associated with smaller deviations from ambiguity neutrality. The results for all of the other weather variables are insignificant or unstable, possibly due to the low, inconsistent influence of these variables on the respondents' affective states.

Our results also replicate those of Dimmock et al. (2013), who found that age, incentives and education correlate with ambiguity attitudes, whereas gender, working status and financial situation are not significantly associated with ambiguity attitudes. In particular, highly educated respondents behave more in line with ambiguity neutrality in this sample (they have lower probability equivalents for the "1 color out of 10" task and higher probability equivalents for the "9 colors out of 10" task). Financial incentives in the survey consistently lead to more ambiguity aversion (lower probability equivalents), whereas older respondents are consistently less ambiguity averse across the three tasks.

We tested whether the respondents in the incentivized version of the ambiguity survey reacted in the same way to the weather as the respondents who made purely hypothetical decisions. For this purpose, we used a generalized version of the Chow test (Chow 1960, Gujarati 1970) for sample poolability, i.e., running OLS in the combined sample and including interaction terms between the weather variables and the incentive dummy. Our results showed no evidence that the respondents who played for real money were less affected in their decisions by cloudiness (see Appendix C, Table C3).

Table 8: OLS regressions on probability equivalents

	1 color out of 10		**1 color out of 2**		**9 colors out of 10**	
	Beta	*SE*	*Beta*	*SE*	*Beta*	*SE*
Temperature	-0.01	0.03	-0.02	0.03	-0.05	0.03
Sunshine duration	-0.01	0.04	0.07	0.04	0.05	0.04
Precipitation duration	-0.03	0.03	-0.04	0.03	-0.04	0.03
Cloudiness	0.07	0.05	0.12**	0.05	0.11**	0.05
Mistiness	-0.02	0.03	-0.03	0.03	-0.04	0.03
Incentive	-0.09***	0.03	-0.06**	0.03	-0.05**	0.03
Female	0.01	0.03	-0.02	0.03	0.00	0.03
Education	-0.05*	0.03	-0.00	0.03	0.08***	0.03
Age	0.14***	0.03	0.12***	0.03	0.09***	0.03
Working status	-0.02	0.03	-0.02	0.03	-0.02	0.03
Financially satisfied	-0.04	0.03	-0.02	0.03	0.02	0.03
Model diagnostics						
N	1,550		1,550		1,550	
Prob. > *F*	0.00		0.00		0.00	
R^2	3.9%		2.3%		1.8%	

*Note: Betas are standardized. * p < 0.10, ** p < 0.05, and *** p < 0.01.*

6. Discussion

The results of our three independent studies are consistent and point in the same direction: sadness and cloudiness (which is often considered to trigger sadness) lead to fewer deviations from payoff-maximizing behavior in ambiguous situations. In the ambiguity tasks studied here, both ambiguity aversion and ambiguity seeking can be viewed as suboptimal because they decreased the expected monetary payoffs of the subjects. Furthermore, diversions from ambiguity neutrality can even be deemed irrational because they lead to violations of dynamic consistency or of consequentialism (see, for instance, Al-Najjar and Weinstein 2009). Hence, the "wise" strategy in our studies was to be ambiguity neutral. We found such payoff-maximizing behavior more frequently among subjects in the sadness groups in Studies 1 and 2 and by those who responded to the LISS survey (Study 3) on cloudy days.

Even though sadness did not have a statistically significant effect for all tasks, the effects we observed were consistent in the same direction and compatible with more analytic information processing. This improved information processing could indeed be expected from an affective state with a negative valence (Andrews and Thompson 2009, Mackie and Worth 1989, Schwarz 1990, Schwarz and Clore 1996). However, the valence dimension cannot fully explain our results. In line with the valence perspective, fear as a negative affective state should also lead to more analytic and focused information processing and in turn to less deviation from profit-maximizing behavior. Instead, the arousal dimension of affect may be vital to understand the differential effects of sadness and fear.

Affective states high on arousal are generally supposed to inhibit information processing (Sanbonmatsu and Kardes 1998). Hence, an arousal perspective would suggest that affective states that are high on arousal (happiness, fear) lead to less structured information processing compared with affective states that are low on arousal (sadness). However, there are also findings that are inconsistent with this perspective, showing that fear, a negatively valenced but arousing affective state, promotes structured, systematic and focused thinking and attention to detail (Baas et al. 2011, Friedman and Förster 2010, Lerner and Keltner 2000, 2001, Tiedens and Linton 2001), encoding of information into detailed conceptual categories (Mikulincer et al. 1990), and systematic idea generation (De Dreu et al. 2008). Hence, although the effects of fear as a high arousal affect on information processing were shown to be mixed in existing studies, our results are in line with early studies that suggested that a high arousing affect is associated with inhibited information processing (e.g., Sanbonmatsu and Kardes 1998). Therefore, the different effects of sadness and fear on ambiguity attitudes may be explained by their different arousal levels and their associated information-processing mode.

With regard to the effects of joy on ambiguity attitudes, our results suggest that joy has similar effects as fear. Although joy and fear have different valence levels, they may both be regarded as arousing affective states that seem to have inhibited the subjects' information-processing mode (e.g., Sanbonmatsu and Kardes 1998). The holistic, intuitive information-processing strategy triggered by joy and by fear possibly leads to a stronger deviation from profit-maximizing behavior in ambiguous decision situations compared with sadness.

In addition to the results regarding affect and ambiguity attitudes, our studies' findings are consistent with earlier results showing a tendency towards ambiguity-seeking behavior for low likelihoods and towards ambiguity aversion for intermediate and high likelihoods in the gain domain

(Wakker 2010 p.292). The latter behavior is a form of *likelihood insensitivity* (behaving as if all likelihoods were close to 50-50) and is often considered to be a cognitive bias (Wakker 2010 p.317). Our results suggest that sadness reduces this cognitive bias because it decreases ambiguity-seeking behavior for small likelihoods and ambiguity aversion for high likelihoods. This result is compatible with more focused information processing triggered by sadness.

Several alternative explanations for our results do not seem very convincing. First, sad people have been found to be more willing to pay to acquire some goods (Cryder et al. 2008). This result could explain why the probability equivalent of the sadness group in the gain task in Study 1 was higher than that of the other groups, but it could not explain why we found the opposite for the triangle task in Study 2 (in which the subjects in the sadness group had a lower probability equivalent, suggesting a lower willingness to bet, than the other groups). Second, it could be claimed that the respondents in Study 3 were more ambiguity neutral on cloudy days because they had more time to dedicate to the questionnaire (the bad weather prevented them from doing other activities). Such an explanation can be ruled out because the fastest answering strategy was to be ambiguity neutral.[7] The subjects should therefore have been *more* ambiguity neutral on sunny days, not less.

Our result that sadness leads to more ambiguity-neutral attitudes may help to explain why stock market returns tend to be lower on cloudy days than on sunny days (Hirshleifer and Shumway 2003, Saunders 1993) as well as on shorter days (i.e., fall and winter, Kamstra et al. 2003). The most common explanation for these phenomena is that investors' moods could be influenced by these exogenous events (e.g., due to seasonal affective disorder), which may influence their *risk* preferences and in turn influence investment decisions and market outcomes. Yet, Watson and Funck (2012) showed that short selling (a risky investment strategy) by professional traders actually increases on cloudy days, but not on the three prior days before the cloudy event. This suggests that professional traders do not correctly anticipate downward market movements based on weather forecasts. Instead, even professional short sellers seem to be affected in their investment decisions by weather events, but not in a way that would be consistent with higher risk aversion on cloudy days.

We suggest that these inconsistencies may be resolved by taking the influence of ambiguity attitudes on trading behavior into account. Specifically, Dow and Werlang (1992) and Bossaerts et al. (2010) find that ambiguity aversion leads to decreased market participation, while Dimmock et al. (2013) show that ambiguity-generated insensitivity has the same effect. According to these findings, more ambiguity-neutral attitudes should lead to greater market participation. The sadness-induced shift towards ambiguity-neutrality that we document in this study is thus consistent with both the lower market returns and the higher participation of short sellers on cloudy days.

[7] In the bisection procedure explained above, being indifferent (i.e., indicating no preference) in the first choice would signal ambiguity neutrality and stop the elicitation immediately.

7. Conclusion

Our study identifies affect as a transient cause of ambiguity attitudes, with sadness leading to more ambiguity-neutral, payoff-maximizing behavior. Thus, typically unobserved differences in affective states among people can contribute towards heterogeneity in ambiguity attitudes. Given the prevalence of ambiguous decision environments, our results suggest that random, exogenous fluctuations in people's affective states could influence a broad spectrum of economic behavior through their impact on ambiguity attitudes, such as financial investments, innovation or market entry. An open question is whether individuals could learn to overcome the temporary preference shocks of their moods or, alternatively, if affect is a necessary component of the human ability to think and behave (Damasio 2005), with its potentially negative side effects (Schelling 1984).

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Appendix A: Study 1

Pretest with film clips for Study 1

To prepare for Study 1, we conducted a pretest with 50 students (4 sessions) in a Dutch university's behavioral laboratory in April 2010 to check the effectiveness of the film clips, and we measured affects with three subscales (joviality, fear, sadness) from the Positive And Negative Affect Schedule (PANAS-X, Watson and Clark 1994). In this pretest, we used film clips recommended by Gross and Levenson (1995) and Hewig et al. (2005), including "Silence of the Lambs" (1991) to induce a fearful mood. However, unlike the joyful and sad clips, the fearful film clip did not induce fear successfully. Thus, we prepared two new film clips, one from "Halloween" (1978) and one from "Paranormal Activity" (2007), which we showed to 20 friends and colleagues. Based on their judgments, we decided to use a film clip from "Paranormal Activity."

Tasks and questionnaires

At the beginning of the experiment and before the subjects watched the film clips, they completed questions about their socio-economic status, including age, gender, current occupation, level of education, academic major, relationship status, entrepreneurial intentions (Reynolds et al. 2005), risk preferences (Dohmen et al. 2011), Big 5 personality domains (Gosling et al. 2003), and the joviality, fear, and sadness subscale of the PANAS-X (Watson and Clark 1994). After the subjects had watched the film clips, we asked them whether they had seen the film before. Subsequently, the subjects again indicated their affective state on the three PANAS-X subscales.

The experiment contained six decision tasks, two of which were the tasks on ambiguity preferences reported in the main text. The other tasks were two measures of absolute and relative overconfidence (Blavatskyy 2009, Urbig et al. 2009) and two tasks on risk preferences involving gains and losses (Holt and Laury 2002). After all of the experimental tasks were completed and before the subjects drew their payoff, we asked them about their general positive and negative affect (PANAS-X, Watson and Clark 1994) to check how long the affect induction lasted.

Effect of movies on self-reported moods in Study 1

Within-subject differences in self-reported moods from the PANAS-X measures before and after the movie clip were in line with our desired mood induction. We report here the means (M), standard errors (SE), paired t-tests (t and p), and Cohen's ds. The subjects in the joyful group reported that their joy before induction ($M = 2.43$, $SE = 0.09$) was lower than after induction ($M = 2.85$, $SE = 0.11$; $t[df = 69] = -3.85$, $p = 0.00$; $d = 0.93$). In the fear group, fear before induction ($M = 1.14$, $SE = 0.02$) was lower than after induction ($M = 2.13$, $SE = 0.06$; $t[df = 75] = -9.69$, $p = 0.00$; $d = 2.24$). Similarly in the sadness group, sadness before induction ($M = 1.38$, $SE = 0.06$) was lower than after induction ($M = 2.24$, $SE = 0.10$; $t[df = 75] = -7.43$, $p = 0.00$; $d = 1.72$). The effect sizes d indicate that the movies had a relatively large effect on the participants' affects. An ANOVA for self-reported fear

(F [3, 286] = 1.31, $p = 0.27$, *partial* $\eta^2 = 0.01$), sadness (F [3, 286] = 1.03, $p = 0.38$, *partial* $\eta^2 = 0.01$), and joy (F [3, 286 = 1.47, $p = 0.22$, *partial* $\eta^2 = 0.02$) before induction revealed no significant differences between the experimental groups; an ANOVA for self-reported fear (F[3, 289] = 36,02, $p = 0.00$, *partial* $\eta^2 = 0.27$), sadness (F [3, 289] = 39.52, $p = 0.00$, *partial* $\eta^2 = 0.29$), and joy (F [3, 289] = 62.69, $p = 0.00$, *partial* $\eta^2 = 0.39$) after the induction showed differences between the experimental groups.

Appendix B: Study 2

Questions to check exchangeability

Do you agree with the following statements? (I agree / I disagree)

1. I think there are more triangles than squares in Urn B.
2. I have no reason to think that there are more triangles than squares in Urn B.
3. I think there are more triangles than rectangles in Urn B.
4. I have no reason to think that there are more triangles than rectangles in Urn B.
5. I think there are more squares than rectangles in Urn B.
6. I have no reason to think that there are more squares than rectangles in Urn B.

Appendix C: Robustness checks for Study 3

Table C1: OLS regressions on probability equivalents – piecewise exclusion of weather variables other than cloudiness

	Beta	*SE*	*Beta*	*SE*	*Beta*	*SE*	*Beta*	*SE*
	1 color out of 10							
Temperature	-	-	-0.01	0.03	-0.01	0.03	-0.01	0.03
Sunshine duration	-0.01	0.04	-	-	-0.01	0.04	-0.02	0.04
Precipitation duration	-0.03	0.03	-0.03	0.03	-	-	-0.03	0.03
Cloudiness	0.06	0.04	0.08**	0.03	0.06	0.05	0.05	0.04
Mistiness	-0.02	0.03	-0.02	0.03	-0.01	0.03	-	-
Incentive	-0.09***	0.03	-0.09***	0.03	-0.09***	0.03	-0.09***	0.03
Female	0.01	0.03	0.01	0.03	0.01	0.03	0.02	0.03
Education	-0.05*	0.03	-0.05*	0.03	-0.05*	0.03	-0.05*	0.03
Age	0.14***	0.03	0.14***	0.03	0.14***	0.03	0.14***	0.03
Working status	-0.02	0.03	-0.02	0.03	-0.02	0.03	-0.02	0.03
Financially satisfied	-0.04	0.03	-0.04	0.03	-0.04	0.03	-0.04	0.03
Model diagnostics								
N	1,550		1,550		1,550		1,550	
Prob. > *F*	0.00		0.00		0.00		0.00	
R^2	3.9%		3.9%		3.8%		3.9%	
	1 color out of 2							
Temperature	-	-	-0.02	0.03	-0.02	0.03	-0.02	0.03
Sunshine duration	0.06	0.04	-	-	0.07	0.04	0.04	0.04
Precipitation duration	-0.04	0.03	-0.04	0.03	-	-	-0.03	0.03
Cloudiness	0.10**	0.04	0.06*	0.03	0.11**	0.05	0.09**	0.04
Mistiness	-0.03	0.03	-0.01	0.03	-0.02	0.03	-	-
Incentive	-0.06**	0.03	-0.06**	0.03	-0.06**	0.03	-0.06**	0.03
Female	-0.02	0.03	-0.02	0.03	-0.02	0.03	-0.02	0.03
Education	-0.00	0.03	-0.00	0.03	-0.00	0.03	-0.00	0.03
Age	0.12***	0.03	0.12***	0.03	0.12***	0.03	0.12***	0.03
Working status	-0.02	0.03	-0.02	0.03	-0.02	0.03	-0.02	0.03
Financially satisfied	-0.02	0.03	-0.02	0.03	-0.02	0.03	-0.02	0.03
Model diagnostics								
N	1,550		1,550		1,550		1,550	
Prob. > *F*	0.00		0.00		0.00		0.00	
R^2	2.3%		2.2%		2.2%		2.2%	
	9 colors out of 10							
Temperature	-	-	-0.04	0.03	-0.05	0.03	-0.04	0.03
Sunshine duration	0.04	0.04	-	-	0.05	0.04	0.02	0.04
Precipitation duration	-0.04	0.03	-0.04	0.03	-	-	-0.03	0.03
Cloudiness	0.08*	0.05	0.07**	0.03	0.10*	0.05	0.07*	0.04
Mistiness	-0.04	0.03	-0.03	0.03	-0.03	0.03	-	-
Incentive	-0.05*	0.03	-0.05*	0.03	-0.05*	0.03	-0.05*	0.03
Female	0.00	0.03	0.00	0.03	0.00	0.03	0.01	0.03
Education	0.08***	0.03	0.08***	0.03	0.09***	0.03	0.08***	0.03
Age	0.09***	0.03	0.09***	0.03	0.09***	0.03	0.09***	0.03
Working status	-0.02	0.03	-0.02	0.03	-0.02	0.03	-0.02	0.03
Financially satisfied	0.02	0.03	0.02	0.03	0.02	0.03	0.02	0.03
Model diagnostics								
N	1,550		1,550		1,550		1,550	
Prob. > *F*	0.00		0.00		0.00		0.00	
R^2	1.6%		1.7%		1.7%		1.7%	

Note: Betas are standardized. $^{*} p < 0.10$, $^{**} p < 0.05$, *and* $^{***} p < 0.01$.

Table C4: OLS regressions on probability equivalents, including additional weather variables

	1 color out of 10		1 color out of 2		9 colors out of 10	
	Beta	*SE*	*Beta*	*SE*	*Beta*	*SE*
Temperature	-0.04	0.05	-0.01	0.05	-0.09	0.05
Sunshine duration	0.00	0.05	0.08	0.05	0.07	0.05
Precipitation duration	-0.06	0.07	-0.06	0.07	-0.11*	0.07
Cloudiness	0.09	0.06	0.11*	0.06	0.13**	0.06
Mistiness	-0.00	0.05	-0.06	0.05	-0.03	0.05
Rain	0.03	0.06	0.03	0.06	0.08	0.06
Snow	0.02	0.07	0.03	0.07	0.06	0.07
Ice formation	-0.04	0.08	0.02	0.08	-0.07	0.08
Incentive	-0.09***	0.03	-0.06**	0.03	-0.05*	0.03
Female	0.01	0.03	-0.02	0.03	0.00	0.03
Education	-0.05*	0.03	-0.01	0.03	0.08***	0.03
Age	0.14***	0.03	0.12***	0.03	0.09***	0.03
Working status	-0.02	0.03	-0.02	0.03	-0.02	0.03
Financially satisfied	-0.04	0.03	-0.02	0.03	0.02	0.03
Model diagnostics						
N	1,550		1,550		1,550	
Prob. > *F*	0.00		0.00		0.00	
R^2	3.9%		2.4%		1.9%	

*Note: Betas are standardized. * p < 0.10, ** p < 0.05, and *** p < 0.01.*

Table C5: OLS regressions on probability equivalents, poolability test for incentive group versus non-incentive group

	1 color out of 10		1 color out of 2		9 colors out of 10	
	Beta	*SE*	*Beta*	*SE*	*Beta*	*SE*
Temperature	-0.01	0.04	-0.05	0.04	-0.06	0.04
Temperate*Incentive	-0.00	0.04	0.05	0.04	0.02	0.04
Sunshine duration	-0.10	0.06	0.09	0.06	0.08	0.06
Sunshine*Incentive	0.15**	0.07	-0.04	0.07	-0.06	0.07
Precipitation duration	-0.05	0.04	-0.05	0.04	0.01	0.04
Precipitation*Incentive	0.03	0.04	0.02	0.04	-0.08*	0.04
Cloudiness	0.02	0.07	0.15**	0.07	0.12*	0.07
Cloudiness*Incentive	0.25	0.22	-0.15	0.22	-0.04	0.22
Mistiness	0.00	0.04	-0.07	0.04	-0.03	0.04
Mistiness*Incentive	-0.04	0.05	0.06	0.05	-0.02	0.05
Incentive	-0.40*	0.23	0.08	0.23	0.07	0.23
Female	0.02	0.03	-0.02	0.03	0.00	0.03
Education	-0.05*	0.03	-0.00	0.03	0.08***	0.03
Age	0.14***	0.03	0.12***	0.03	0.09***	0.03
Working status	-0.02	0.03	-0.02	0.03	-0.02	0.03
Financially satisfied	-0.04	0.03	-0.02	0.03	0.02	0.03
Model diagnostics						
N	1,550		1,550		1,550	
Prob. > *F*	0.00		0.00		0.01	
R^2	4.2%		2.5%		2.1%	

*Note: Betas are standardized. * p < 0.10, ** p < 0.05, and *** p < 0.01.*