Journal of Behavioral Decision Making, *J. Behav. Dec. Making* (2011)
Published online in Wiley Online Library (wileyonlinelibrary.com) **DOI:** 10.1002/bdm.754

Protecting Against Low-Probability Disasters: The Role of Worry

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ABTRACT

We carry out a large monetary stakes insurance experiment with very small probabilities of losses and ambiguous as well as exact probabilities. Many individuals do not want to pay anything for insurance whether the probabilities are given exactly or are ambiguous. Many others, however, are willing to pay surprisingly large amounts. With ambiguity, the percentage of those paying nothing is smaller and the willingness to pay (WTP) of the other individuals larger than with exact probabilities. Comparing elasticities with ambiguity, we find that worry is much more important than subjective probability in determining WTP for insurance. Furthermore, when the ambiguous loss probability is increased by a factor of 1000, it has almost no effect on WTP.

KEY WORDS low-probability disasters; ambiguity; large stake experiment; worry; protective decisions

INTRODUCTION

There is empirical evidence that many individuals exhibit behavior that implies they are either unconcerned or extremely risk averse when deciding whether to purchase insurance against events that have a small probability of occurring (Kunreuther, 1978; McClelland, Schulze, & Coursey, 1993; Slovic, Fischhoff, Lichtenstein, Corrigan, & Combs, 1978). The unconcerned individuals are not willing to pay a penny even if premiums are subsidized, whereas those who appear to be highly risk averse opt for premiums that are more than 10 times the expected losses. There is additional evidence from controlled experiments that people have a difficult time comprehending the meaning of small probabilities (Kunreuther, Novemsky, & Kahneman, 2001).

Self-reports of worry have been shown to be related to individuals' tendencies to protect themselves against potential losses (Baron, Hershey, & Kunreuther, 2000). These findings are consistent with many other studies on the role that affect and emotions play in decision making with respect to protective measures (Hogarth & Kunreuther, 1995; Hsee & Kunreuther, 2000; Loewenstein, Weber, Hsee, & Welch, 2001; Rottenstreich & Hsee, 2001; Slovic, Finucane, Peters, & MacGregor, 2002). However, the impact of cognitive and emotional drivers of willingness to pay (WTP) for insurance with very small probabilities of disaster has not been documented in these studies.

This study provides answers to the following three questions:

(1) Are there any differences with respect to the WTP for insurance when the probabilities are ambiguous (Ellsberg, 1961) or exact in case the probability of a disaster is very small?
(2) What is the *relative importance of worry* (as an emotion) and *subjective probability* (as a cognitive aspect) for WTP for insurance when the probability of a disaster is very small?
(3) How sensitive are individuals' WTP to large increases in the ambiguous probability of disaster?

We designed an experiment where two randomly selected individuals could each lose US$1100 should one of two hazards occur and they do not have insurance. However, although those payoffs were in real money, our experiment was designed in a way that no participant could have left with a negative net balance (i.e., paying something to the experimenter); hence, we did not run into any ethical or legal issues (for more details, see the Method section).

Consistent with the results of McClelland et al. (1993), our findings show that a substantial percentage of individuals are not willing to pay anything for insurance when the probabilities of losses are either exact or ambiguous whereas others tend to be willing to pay surprisingly large amounts. In line with other research (e.g., Curley, Yates, & Abrams, 1986; Hogarth & Kunreuther, 1985), WTP is higher when probabilities are ambiguous than when they are known. Strikingly, worry appears to be a major driver of WTP for insurance, whereas subjective probability judgments have hardly any impact.

METHOD

Nature of the experiment

Participants were told that they had inherited a painting (part A of the experiment) or a sculpture (part B) and received small photos of the respective art object with individual identification numbers. At the start of the experiment, everyone learned that only one painting and one sculpture were originals worth 2000 DM that could be converted into an equivalent cash amount. If the piece of art was a forgery, then it had zero value. The two individuals with the original painting and sculpture

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were determined by random draws at the end of the experiment. This is an application of the random pay mechanism suggested and investigated by Bolle (1990).

Sample

A total of 263 students from Goethe-Universität, Frankfurt/M., participated in the experiment. They were recruited via email, posters, and short presentations in classrooms and were told that the experiment would take 90 min; all participants would receive 10DM for sure, and there was a small chance (not specified) that they would end up with 2000 DM in real cash at the end of the experiment (approximately US$1100 at the time of the experiment). The study was carried out in groups of 6 to 10 students, each of whom was situated in a separate booth. Of the 263 respondents, nine were eliminated from the study either because they bid more for insurance than the value of the art object (2000 DM) or because they mistakenly thought they were bidding for the art object and not for insurance. (They indicated this in their response to an open-ended question at the end of the experiment on how they determined WTP.) Hence, the sample size was reduced to 254 respondents.

Experimental conditions

The experimental design is depicted in Table 1. Group 1 individuals were asked to state their maximum WTP for insurance against each of two hazards (fire and theft) with respect to a painting (part A) and a sculpture (part B). Group 2 differed only in that respondents in parts A and B were asked to state their maximum WTP for one insurance policy covering the two hazards. Group 3 (part A) looked at stepwise purchase of insurance that is unrelated to the aspects of interest in this paper and will not be analyzed here. Group 3 (part B) presented subjects with a much higher ambiguous probability than the ones given to groups 1 and 2 (part B).

Nature of the risks and timing

In all conditions and in both parts of the experiment, the original painting or sculpture was threatened by fire and theft, and the participants were offered insurance protection against a potential loss of 2000 DM. They were told that the insurer would sell a policy only to the owner of the original art object; insurance purchased by others would be treated as hypothetical and not affect their final wealth level. In other words, only the owner of the original painting or sculpture would have to pay for coverage. We indicated that it was in everyone's best interest to anticipate being the owner of the respective original art object when determining the maximum amount they would be willing to pay for an insurance policy. In addition to providing written instructions, we presented a flow diagram to subjects, describing the key variables and the decisions they had to make. All questions were answered, and the procedure was explained again when necessary. The instructions are reported in Appendix A.

In part A of the experiment, each participant inherited a painting. Groups 1 and 2 were told that the original was threatened by the following ambiguous risk: the painting was declared to be stolen if it rained exactly 24 days in July in the current year at the Frankfurt airport similarly, a fire occurred and destroyed the painting if it rained exactly 23 days at the Frankfurt airport in August. Subjects were informed that a rain day occurs if the weather station at the Frankfurt airport reports that there was more than 1 mm of precipitation during the relevant 24-hour period. No probability estimates for these events were provided. However, it was made clear that the occurrence of those events would actually determine a loss of 2000 DM for the one individual who owned the real painting if she were uninsured. As the experiment was carried out in April and May, the participants knew that they would only learn if the painting was impacted by a fire or theft several months after they made their decision on whether or not to purchase insurance.

We define *ambiguity* as a state of mind in which the *decision maker* perceives difficulties in estimating the relevant probabilities (Camerer & Weber, 1992). Whereas rain frequencies may be precisely estimated by meteorologists, they will be ambiguous for most if not all the participants in the experiment. This situation was designed to resemble a real-life risk (e.g., a fire or theft in one's home) where insurers estimate annual loss probabilities across all policyholders, but the individual homeowner views these risks as ambiguous. The of actual Frankfurt weather data from the year 1870 to the time of the experiment turned out to be consistent with

Table 1. Experimental design

		Within subjects	
		Part A of experiment: painting	Part B of experiment: sculpture
Between subjects	Group 1 ($n=87$)	Rain frequencies in July and August each with probability of one in 10 000—separate insurance policies for theft and fire	Two precise risks, each with probability of one in 10 000—separate insurance policies for theft and fire
	Group 2 ($n=81$)	Rain frequencies in July and August each with probability of one in 10 000—one insurance policy for theft and fire	Two precise risks, each with probability of one in 10 000—one insurance policy for theft and fire
	Group 3 ($n=86$)	Rain frequencies in July and August each with probability of one in 10 000—first insurance sold before second risk introduced	Rain frequencies in July and August, each with probability of one in 10—separate insurance policies for theft and fire

Note: An inherited object was threatened by theft and fire in all treatments. Subjects were offered insurance against these risks, and the willingness to pay for the insurance was elicited. Part A of group 3 faced the same small ambiguous high probabilities as part A of groups 1 and 2 but the first insurance for fire was sold before the second risk for theft was introduced. Therefore, part A of group 3 is not strictly comparable with the other treatments and excluded from further analysis.

DOI: 10.1002/bdm

a Poisson distribution. On the basis of this distribution, we then estimated the probability of each of the above events occurring to be approximately one in 10 000.

In part B of the experiment, the participants in groups 1 and 2 were told that a sculpture was threatened by theft and fire, each of which was specified as having a probability of one in 10 000 of occurring. A sculpture instead of a painting was chosen, so respondents viewed this treatment as a new experimental situation. For us to determine whether a fire had occurred, two random draws with replacement were taken from a bingo cage containing 100 balls numbered 1 to 100. A fire would destroy the sculpture only if the number 1 was pulled in both of the random draws. The same procedure was followed to determine whether a theft occurred.

In group 3 in part B of the experiment, respondents had a one in 10 ambiguous chance of either fire or theft. More specifically, a theft occurred if it rained 12 days in July, and a fire occurred if it rained 11 days in August at the Frankfurt airport. We used this relatively high likelihood to see the impact of a significant increase in the ambiguous probability of a loss on WTP for insurance compared with the premiums that individuals in groups 1 and 2 were willing to pay for protection.

Note that in groups 1 and 2, the ambiguous low-probability situation is always presented first. If we had initially presented the exact probabilities scenario to some of the respondents, they might have anchored on this figure when estimating the likelihood of rain in Frankfurt, potentially distorting our results on ambiguity.

Eliciting willingness to pay for insurance

Rather than specifying premiums for the insurance policies, we utilized a modified Becker, DeGroot, and Marschak (BDM) (1964) mechanism for eliciting maximum WTP values.

In the original BDM mechanism, individuals face a random draw of a market price from a pre-specified interval, for example, containing balls numbered from 0 to 100, corresponding to prices from US$0 to US$100. Because an insurance decision involves loss probabilities, individuals would have faced two probability distributions: a loss due to theft or fire and the chance of a specific price being drawn for determining the market price of insurance. Although the maximum WTP specified by a rational decision maker would not have been affected by the complexity of this setup, Safra, Segal, and Spivak (1990) indicated that decision makers being asked for their WTP for a risky good using the standard BDM mechanism are likely to reduce the resulting two-stage to a one-stage lottery (processing only one joint probability distribution with the respective outcomes) and may make errors in doing so. Pre-specified intervals of WTP in the original BDM procedure may also serve as anchors, thus biasing individuals' estimates (Bohm, Lindén, & Sonnegard, 1997).

In the modified BDM procedure we used, the actual selling prices for each of the insurance policies were inserted in sealed envelopes to be opened only after the experiment was conducted, thus precluding such a bias. This undisclosed price was selected before the start of the experiment on the basis of pre-test results with respect to WTP, so that about one-half of the respondents' bids could be expected to be higher than the pre-determined price. There was no specific reason for choosing this price with respect to the experimental procedure; it gave respondents a reasonable chance of purchasing insurance. The modified BDM mechanism was first introduced in a laboratory research by Schade and Kunreuther (2001) and has recently been used in the marketing literature to reveal reservation prices at the point of purchase (Wang, Venkatesh, & Chatterjee, 2007).

The mechanism was carefully explained to the subjects so that they understood that it was in their best interest to specify a maximum WTP for insurance. We noted that if they bid too high, they might actually pay that price for insurance should they be the owner of the original art object and regret having made such a high offer. If they bid too low, they might not qualify for insurance even though they would have been willing to purchase coverage at a higher price than their stated value. Respondents were then asked to write their maximum WTP for insurance on a piece of paper and place it in an envelope.

Eliciting subjective probability estimates

After stating maximum buying prices for insurance, the respondents were asked to estimate the probability of each of the ambiguous risks. We distributed tables with likelihoods of a loss ranging from certainty to one in 10 000 000. The event (the number of rain days in Frankfurt in July or August) whose likelihood the respondents were to judge was stated at the top of each probability table (Appendix B). Respondents were first asked to mark the probability of a fire or theft causing a loss in one of 15 intervals specified in Appendix B. Respondents could also indicate that the risk was less than one in 10 000 000. After they checked one of the intervals, they were then asked for their best point estimate of a probability of a loss.

Eliciting the level of worry

After completing parts A and B of the experiment, subjects were asked the following question:

How worried were you that if you were the owner of the original painting (sculpture), that you would lose the money? (This is a translation of the following question in German: "Wie besorgt waren Sie, der Besitzer des echten Gemäldes zu sein und das Geld wieder zu verlieren?")

Worry was neither defined, specified, nor associated with the elements of risk: magnitude of loss or likelihood of loss. Rather we kept the question more general so as to elicit the emotional state of the respondent when the person faced a given scenario. Subjects answered using a 10-point rating scale with 1 = *not worried at all* to 10 = *very worried*.

Towards the end of the experiment, individuals were also asked to fill out the 25-item worry domains questionnaire (WDQ) by Tallis, Eysenck, and Mathews (1992), which measures a general tendency to worry.

DOI: 10.1002/bdm

RESULTS

General considerations

The distributions of subjective probability as well as of WTP are highly skewed. Hence, our descriptive analysis for these variables is based on medians instead of means. For the sake of simplicity, our analyses focus on the joint probability of both fire and theft as well as WTP for insurance against both hazards. We computed the probability of a loss from either fire or theft to be approximately 1/5000 for groups 1 and 2 and one in five for group 3 (the exact number is 0.19, in the latter case).

With two measurements of WTP from each of the 254 respondents, we generated 508 observations of the dependent variable. Group 3A was omitted from the analysis for methodological reasons (see the Method section), reducing the number of observations to 422. An additional 17 observations were excluded because participants bid more for insurance than 10 000 times the expected loss (based on their subjective probabilities).

Willingness to pay and subjective probabilities in the different experimental treatments

For events with very small probabilities of losses, individuals in groups 1 and 2 are willing to pay much more when the probability is ambiguous than when it is precise as shown in Table 2. This finding conforms with other empirical data indicating aversion to ambiguity (see, e.g., Curley, Yates, & Abrams, 1986; Hogarth & Kunreuther, 1985). The very high WTP of many individuals in our experiment is consistent with findings by Laury, McInnes, and Swarthout (2009) where subjects in a controlled laboratory experiment were willing to buy insurance policies that cost large multiples of the expected loss.

Table 3 reveals that when the probabilities of a fire or theft are exact but very small, slightly more than one-third of the individuals will not pay anything for insurance when faced with either a separate or aggregated risk. Similar findings, albeit far less extreme, have been reported by McClelland et al. (1993) for an exact loss probability of 1%. The percentage of individuals who specify $WTP = 0$ for insurance is much lower when the risk is ambiguous for either separate risks (13%) or aggregated risks (20%).

As shown in Table 4, when the risk of a loss is ambiguous, individuals greatly overestimate the likelihood of a fire or theft when the probabilities are very small (i.e., one in 5000) and slightly underestimate these likelihoods when the risk is relatively high (one in five). Whereas the difference between these two subjective probability judgments is statistically significant for individuals with $WTP > 0$ (Table 4), increasing the ambiguous loss probability by a factor of 1000 has no significant effect on either WTP or the percentage of those not willing to pay anything for insurance (Tables 2 and 3).

Table 2. Median willingness to pay across treatments

	Ambiguity	Known risk	Kruskal–Wallis test between ambiguous and known risk ($df = 1$)
Low risk (1/5000), separate insurance policies	100 DM[a]	10 DM[b]	$p = 0.0001$
Low risk (1/5000), one insurance policy	80 DM[c]	5 DM[d]	$p = 0.0002$
High risk (one in five), separate insurance policies	120 DM[e]		
Kruskal–Wallis test between low and high risk with separate insurance ($df = 1$)	$p = 0.72$[f]		

Note: 17 observations with unreasonable responses are excluded.
Definition of treatment groups:
[a]Group 1A, $N = 78$. Expected value of loss was 0.4 DM.
[b]Group 1B, $N = 87$. Expected value of loss was 0.4 DM.
[c]Group 2A, $N = 76$. Expected value of loss was 0.4 DM.
[d]Group 2B, $N = 81$. Expected value of loss was 0.4 DM.
[e]Group 3B, $N = 83$. Expected value of loss was 380 DM.
[f]Comparison of groups 1A and 3B.

Comparing relative impact of worry and subjective probability using elasticities

To examine the relative importance of worry and probabilities on WTP, one can undertake a statistical regression analysis where *WTP* is the dependent variable and *worry* and *subjective probability* are the two independent variables. Because of the number of individuals who indicated $WTP = 0$, we ran a Tobit regression (Tobin, 1958; Wooldridge, 2002, pp. 517–529), the standard econometric technique for dealing with censored response variables such as $WTP \geq 0$. A censored variable, such as WTP, is a dependent variable where some values, in this case $WTP < 0$, are impossible but might have been predicted from the values of the

Table 3. Share of subjects with $WTP = 0$ across treatments

	Ambiguity	Known risk	Chi^2 test between ambiguous and known risk ($df = 1$)
Low risk (1/5000), separate insurance policies	13%[a]	36%[b]	$p = 0.001$
Low risk (1/5000), one insurance policy	20%[c]	35%[d]	$p = 0.04$
High risk (one in five), separate insurance policies	13%[e]		
Chi^2 test between low and high risk with separate insurance ($df = 1$)	$p = 0.94$[f]		

Note: 17 observations with unreasonable responses are excluded.
Definition of treatment groups:
[a]Group 1A, $N = 78$. Expected value of loss was 0.4 DM.
[b]Group 1B, $N = 87$. Expected value of loss was 0.4 DM.
[c]Group 2A, $N = 76$. Expected value of loss was 0.4 DM.
[d]Group 2B, $N = 81$. Expected value of loss was 0.4 DM.
[e]Group 3B, $N = 83$. Expected value of loss was 380 DM.
[f]Comparison of groups 1A and 3B.

DOI: 10.1002/bdm

Table 4. Median probability judgments

	$WTP=0$	$WTP>0$	Average	Kruskal–Wallis test between subjects with $WTP=0$ and $WTP>0$ ($df=1$)
Low risk (1/5000), separate insurance policies[a]	1/61 ($N=10$)	1/35 ($N=68$)	1/37 ($N=78$)	$p=0.002$
Low risk (1/5000), one insurance policy[b]	1/35 ($N=15$)	1/44 ($N=61$)	1/44 ($N=76$)	$p=0.08$
High risk (one in five), separate insurance policies[c]	1/16 ($N=10$)	1/10 ($N=73$)	1/10 ($N=83$)	$p=0.58$
Kruskal–Wallis test between low and high risk with separate insurance ($df=1$)[d]	$p=0.08$	$p=0.002$		

Note: 17 observations with unreasonable responses are excluded.
Definition of treatment groups:
[a]Group 1A.
[b]Group 2A.
[c]Group 3B.
[d]Comparison of groups 1A and 3B.

independent variables. To *compare* the effects of subjective probabilities and worry on WTP, we report on the *elasticities*, a measure frequently used by economists so that the independent variables are all on the same scale. Elasticity is defined as the ratio of the percent change in one variable to the percent change in another variable. Formally, elasticity (E) is defined as follows:

$$\varepsilon_{y,x} = \frac{\mathrm{d}y}{\mathrm{d}x} \cdot \frac{x}{y}$$

Our specific interest is in comparing the elasticities of the independent variables *subjective probability* and *worry* with WTP as the dependent variable. In Table 5, subjective probabilities have a statistically significant impact on WTP, but the elasticity is only 0.19. In other words, WTP increases by only 19% when probability judgments increase by 100%. For a given loss (as in our experiment), both expected utility or expected value models would imply that WTP should increase by the same percentage as the probability increases—100% in this case rather than 19%.

Table 5. Tobit estimation results on WTP for insurance against disasters with large and small ambiguous probabilities

	$Y=WTP$	
	Elasticity	($P>\|z\|$)
Probability judgment	0.19	(0.04)
Worry	0.90	(0.00)
Separate policies[a]	−0.21	(0.05)
High-risk treatment	−0.09	(0.39)
Model diagnostics		
# observations	237	
# left censored	35	
Prob > chi^2	0.00	
Log likelihood	−1475	

Note: 17 observations with unreasonable responses are excluded.
[a]Included for statistical reasons; not analyzed in this paper.

The finding that probability judgments do not appear to explain the premiums that individuals are willing to pay for insurance is underlined by the Kruskal–Wallis test that indicates a non-significant difference between groups 1A and 3B (Table 2). This finding is actually replicated in the Tobit regression results detailed in Table 5 where the dummy-coded "high-risk treatment" variable takes on the value 0 for group 1A (*low risk*) and 1 for group 3B (*high risk*). Increasing the likelihood of loss by a factor of 1000 does not affect WTP directly because the elasticity of the high-risk treatment dummy turns out to be non-significant.

The Tobit regression results reported in Table 5 also indicate that the elasticity of the worry variable with respect to WTP is highly statistically significant. Its elasticity value of 0.9 implies that when a person's worry score doubles, her WTP for insurance almost doubles. For an illustration of the significant effect of worry on the premiums that individuals are willing to pay for insurance, Table 6 reports on median values of WTP for individuals having worry scores between 1 and 5 versus individuals having worry scores between 6 and 10. Those individuals with high worry scoreshave a WTP that is 2.4 times larger than those with a low worry score.

Ruling out alternative explanations of the impact of worry

There are two principal reasons why the relationship between worry and WTP might be a spurious one. We examine them in the following and show why they can be ruled out on the basis of the analysis of the data from the experiments.

Explanation 1: the level of worry is a proxy for subjective probability

To determine whether this is the case, we compute the correlation between subjective probability judgment and worry for high and low risks when the likelihood of a fire and theft are ambiguous. The data in Table 7 show that the Pearson correlation coefficients were low and non-significant for those who indicated they would not pay anything for insurance and those whose $WTP>0$ as well as for both cases

Table 6. Worry and median willingness to pay

	Median WTP
Worry: [1; 5]	95 DM ($N=254$)
Worry: [6; 10]	232 DM ($N=151$)
Average	($N=405$)
Kruskal–Wallis	$p=0.001$
t-test	$p<0.001$

Note: All observations except group 3A included. Subjects from groups 1 and 2 have two observations for WTP and worry. The *t*-test between groups is calculated using clustered robust standard errors.

DOI: 10.1002/bdm

Table 7. Pearson correlation coefficients between probability judgment and worry

	Ambiguity and low risk (1/5000)[a]	Ambiguity and high risk (one in five)[b]
$WTP=0$	0.13 (0.54)	−0.36 (0.31)
$WTP>0$	0.04 (0.63)	0.15 (0.22)
Total	0.08 (0.31)	0.05 (0.61)

Note: 17 observations with unreasonable responses are excluded.
Significance levels are reported in parentheses.
[a]Groups 1A and 2A, $N=154$.
[b]Group 3B, $N=83$.

combined. These data indicate that worry and subjective probability are independent variables.

Explanation 2: individuals justify their willingness to pay by their worry ratings

Even though there were a large number of intervening questions between elicitation of WTP, the probability table, and the worry question, we tested whether the effect of worry could also be due to ex post justification. In other words, did those individuals with a large WTP specify high levels of worry to justify their choices? Note that this would be an explanation contrary to what we suggested above: instead of worry driving WTP, this explanation would argue that WTP drives self-reports of worry. Using an *instrumental variables regression*, we found no evidence of this type of reverse causality. This procedure is explained in detail in Appendix C.

A check of robustness: role of worry for willingness to pay with exact versus ambiguous probabilities

As a robustness check of our results, we also examined the Spearman rank correlations between worry and WTP in groups 1 and 2 separately for the case where probabilities are ambiguous (part A) and the case where probabilities are known (part B). In both cases, the correlation coefficient is almost identical (0.31 and 0.35, respectively) and highly significant ($p=0.0001$ and $p<0.0001$, respectively). Furthermore, including an interaction term between worry and ambiguity in the Tobit regression of Table 5 for groups 1 and 2 yields an insignificant coefficient for the interaction term ($p=0.74$).

DISCUSSION, IMPLICATIONS, AND FUTURE RESEARCH

We are now able to provide answers to the three questions raised in the Introduction section:

(1) When the probability of a loss is ambiguous, fewer individuals specify $WTP=0$ than with exact probabilities. Those who are willing to purchase coverage pay considerably more for insurance when the probability is ambiguous than when it is exact. Both differences are large and statistically significant.
(2) The *relative importance of worry* is much larger than that of *subjective probability* for WTP for insurance when the probability of a disaster is small as indicated by a comparison of the two relevant elasticities.
(3) The comparison of WTP in situations differing by a factor of 1000 in loss probabilities leads to a non-significant effect on WTP.

With exact probabilities, WTP is also far larger than the expected loss, implying that individuals would have to be extremely risk averse if they were expected utility maximizers. When probabilities are ambiguous, individuals are even less likely to comply with the expected utility model for the following reasons:

(a) Subjective probabilities have only a very small impact on WTP (see the above answer to question #2),
(b) Increasing the probability by a factor of 1000 does not have a statistically significant effect on WTP (see the above answer to question #3), and
(c) Other studies indicate that most individuals do not use probabilities in their decision-making process unless they are presented with this information before being asked to make a choice (Hogarth & Kunreuther, 1995; Huber, Wider, & Huber, 1997).

Our experimental findings have important implications for future research. If worry is so important in determining the premiums individuals are willing to pay for insurance against low-probability events, it would be helpful to know what factors actually account for worry. We were able to identify one, albeit weak, factor from our own experimental data. Because we had measured individuals' general worry tendencies using the WDQ, we could calculate the correlation between self-reports of worry in our experimental situation and general worry tendencies. The correlation turned out to be small but significant (0.19; $p<0.01$, $N=237$). Other "candidates" determining the level of worry in a decision situation that might be analyzed in future research are the vividness of potential negative events through TV clips, the behavior of politicians, and/ or personal experience.

Insurance agents also reveal in personal conversations we have had with them that the most effective way to sell insurance is to make people think of how they would feel if something *had happened* to them. And they hardly ever voluntarily provide estimates of the probability of a negative event to their prospective clients and are unlikely to be asked for this information by their customers. Instead, they often show films of factory buildings in flames when they want to sell industry fire insurance, for example. Given our findings, however, this might also be an interesting case for consumer protection organizations to pursue because insurers might take undue advantage of how individuals respond to graphic information.

Using random outcomes with large stakes appears to have helped generate our findings because it might have led individuals to take the experimental situation more seriously and should be considered in future experiments on decision making with respect to low-probability, high-consequence events. It would be useful to supplement these controlled laboratory experiments with field research so as to gain insight into the external validity of the findings reported in this experiment.

DOI: 10.1002/bdm

ACKNOWLEDGEMENTS

We are grateful to Klaus Peter Kaas for his important comments and suggestions regarding the experimental design. We would also like to thank a number of researchers from the University of Pennsylvania, especially Jonathan Baron and Jack Hershey, for the fruitful discussion we had on our planned modification of the Becker–DeGroot–Marschak mechanism. We are also grateful to Frank Yates in his role as editor and two anonymous referees for their extensive and constructive inputs on earlier versions of the paper. We also thank Anna Abratis for her editorial assistance. Support from the German Research Foundation, grant # Scha 816 1/1, the National Science Foundation (grant # SE0959710 at Carnegie Mellon), the National Science Foundation Cooperative Agreement # SES-0345840 to Columbia University's Center for Research on Environmental Decisions, the Travelers Companies, Inc. and the Wharton Risk Management and Decision Processes Center are gratefully acknowledged.

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APPENDIX A: IMPORTANT PARTS OF THE EXPERIMENT CONDITIONS

Group 1 (separate policies)

Part A: ambiguity

- You inherited a small painting and have received a photograph of it. The photo carries an individual identification number. You do not know if the painting is an original or a reproduction. If it is an original, it is worth 2000 DM. If it is a reproduction, it is worth nothing.

- One person in the entire group of respondents participating in our experiment (about 260 to 280 people) has an original painting. All others have reproductions. Which one of the paintings is the original will be determined by a random draw symbolizing the decision of an art appraiser at the end of the entire experiment. The person who has the original painting will actually receive the value of the painting: 2000 DM (in real bills!).
- Theft and fire threaten your painting.
- Whether or not the painting will be stolen will be determined by the weather conditions in July. If it will rain on 24 days in July (not more but also not less), a theft will occur. More precisely, the painting will be stolen if the weather station atthe Frankfurt airport will report on exactly 24 days of rain. A day is defined as a rainy day if there is at least 1 mm of rain on this day.
- The weather conditions in August determine if a fire will destroy the painting. If it will rain on 23 days in August (not more but also not less), a fire will occur. More precisely, a fire will destroy the painting if the weather station at the Frankfurt airport will report exactly 23 days of rain. Here, again, a day is defined as a rainy day if there is at least 1 mm of rain on this day.
- You can buy insurance policies against either each or both of these risks. If you have an insurance policy against theft or fire and the painting will be stolen or destroyed by fire, respectively, the insurance will reimburse you for the loss of 2000 DM. If you have an insurance policy against fire and the painting will be destroyed by fire, the insurance will reimburse you for the value of 2000 DM.
- The insurance company will sell the insurance policy and charge the money for it only in case an art appraiser, represented by the random draw of the experimenter, finds out that your painting is an original. Thus, for all respondents having the reproduction, the payments for the insurance policies will remain hypothetical. However, for the one having the original painting, they will become true and have to be paid from his or her own money.

The selling procedure for the theft insurance policy is organized in the following way:

- Before the experiment, the experimenter selected a secret selling price for the theft insurance policy. He or she wrote it on a piece of paper and put it into the envelope on the front desk.
- You are now required to write a buying price equal to your maximum willingness to pay (WTP) for the theft insurance policy on the form in front of you and to put it in the respective envelope.
- After the experiment, the experimenter will open the envelope with the selling price. If your buying price is equal to or higher than the secret selling price, you will have bought or are able to buy the theft insurance policy should you be the person with the original painting . If your buying price is lower than the secret price, you are not able to buy the theft insurance policy.
- Note that you have no information about the selling price for the theft insurance policy. The experimenter changes this price every time.
- In this situation, the best you can do is to state your true value, your maximum WTP for the theft insurance policy.
- It does not make sense to state a buying price higher than your maximum WTP because you may end up paying this high price.
- It does also not make sense to state a price lower than your maximum WTP. If your stated price is lower than the selling price but you, in fact, would have been willing to pay that price you may end up without the theft insurance policy even if you would have liked to buy it for that price if you are the one who has the original painting.
- If you do not want to buy the theft insurance policy please state 0 DM on the respective form.
- Please do not announce your buying price to the others and do not raise questions that allow the other participants to guess your buying price.
- Again, note that you only have to actually pay the price for the insurance policy if you are the one who has the original painting. This is because the insurance company will only sell the insurance policy if the painting is verified as the original. In this case, the person who has the original painting is able to buy insurance. He or she has to pay for the coverage of the insurance policies from his or her own money.
- Basically, that means that you are buying insurance for the original and that you only pay for it in case you have it.
- Now, please put the form with your maximum buying price in the appropriate envelope and hand it over to the experimenter.

The selling procedure for the fire insurance policy is organized the following way:

- The selling procedure of the fire insurance policy is organized in exactly the same way as the selling procedure for the theft insurance policy, that is, again there is a secret selling price in an envelope, and you again are supposed to state your maximum buying price.
- Now, please put the form with your maximum buying price in the appropriate envelope and hand it over to the experimenter.

Part B: risk

- You inherited a small sculpture and have received a photograph of it. The photo carries an individual identification number. You do not know if the sculpture is an original or a reproduction. If it is an original, it is worth 2000 DM. If it is a reproduction, it is worth nothing.
- One person in the entire group of respondents participating in our experiment (about 260 to 280 people) has an original sculpture. All others are reproductions. Which one of the sculptures is the original will be determined by a random draw symbolizing the decision of an art appraiser at the end of the entire experiment. The person who has the original sculpture will actually receive the value of the sculpture: 2000 DM.

DOI: 10.1002/bdm

•Theft and fire threaten your sculpture. Both risks have a known chance of occurrence:

Hazard	Chance of occurrence
Theft	One of 10 000 cases
Fire	One of 10 000 cases

•A bingo cage with 100 balls will be used to determine whether or not the sculpture will be stolen and whether or not it will be destroyed by fire.
-Whether or not the sculpture will be stolen will be determined by the following two-stage procedure: If a ball with a number between 2 and 100 is drawn, no theft will have occurred. We will continue the drawing of the bingo cage with 100 balls after the first draw only if a ball carrying the number 1 is drawn. Otherwise, nothing happened. In a second draw, another ball from the bingo cage with 100 balls will be taken. Theft occurs if the ball with the number 1 is drawn in the second stage. The chance that both these events occur is exactly 1 in 10 000.
-Secondly, we will determine if fire occurs. We will proceed with the same two-stage procedure as used for the theft situation.
•You can buy insurance policies against either each or both of these risks. If you have an insurance policy against theft or fire and the sculpture will be stolen or destroyed by fire, respectively, the insurance will reimburse you for the loss of 2000 DM. If you have an insurance policy against fire and the fire destroys the sculpture, the insurance will reimburse you for the value of 2000 DM.
•The insurance company will sell the insurance policy and charge the money for it only in case an art appraiser, represented by the random draw of the experimenter, finds out that the sculpture is an original. Thus, for all respondents having the reproduction, the payments for the insurance policies will remain hypothetical. However, for the one having the original sculpture, they will become true and have to be paid from his or her own money.

The selling procedure for the theft insurance policy is organized the following way:
•The selling procedure of the theft insurance policy is organized in exactly the same way as the selling procedure for the theft and fire insurance policies in the first part of the experiment, that is, there is a secret selling price in an envelope, and you again are supposed to state your maximum buying price.
•Now, please put the form with your maximum buying price in the appropriate envelope and hand it over to the experimenter.

The selling procedure for the fire insurance policy is organized the following way:
•The selling procedure of the fire insurance policy is organized in exactly the same way as the selling procedure for the theft and fire insurance policy in the first and the theft insurance policy in the second part of the experiment, that is, there again is a secret selling price in an envelope, and you again are supposed to state your maximum buying price.
•Now, please put the form with your maximum buying price in the appropriate envelope and hand it over to the experimenter.

Group 2 (one policy)
The only difference between groups 1 and 2 was that in group 2 we sold bundled rather than separate insurance in both parts A and B. Therefore, the part of the instructions dealing with insurance was written up as follows in part A (B) of the experiment:
•You can buy an insurance policy against each of these two risks. If you have an insurance policy and your painting (sculpture) will be stolen or destroyed by fire, the insurance will reimburse you for the loss of 2000 DM.

APPENDIX B: PROBABILITY TABLE

Please report how probable you have judged “exactly 24 rain days in July” occurring. Please check an interval that covers the probability you are judging to be correct first. Afterwards, please report the exact probability in the right column.

Explanation: a chance of one in 1 000 000 implies that a July with exactly 24 rain days occurs—on average—every 1 000 000 years.

Chance: 1 in	Please check:	Exactly:
1 to 5		1 in ______________
5 to 10		1 in ______________
10 to 50		1 in ______________
50 to 100		1 in ______________
100 to 500		1 in ______________
500 to 1.000		1 in ______________
1.000 to 5.000		1 in ______________
5.000 to 10.000		1 in ______________
10.000 to 50.000		1 in ______________
50.000 to 100.000		1 in ______________
100.000 to 500.000		1 in ______________
500.000 to 1.000.000		1 in ______________
1.000.000 to 5.000.000		1 in ______________
5.000.000 to 10.000.000		1 in ______________
Less probable		Exactly 1 in ____________

DOI: 10.1002/bdm

APPENDIX C: INSTRUMENTAL VARIABLES REGRESSION

In econometrics, an instrumental variable is a variable that is partially correlated with the explanatory variable, in our case "worry," but not with the error term of the original regression equation. Partial correlation refers to the remaining correlation after netting out the other exogenous variables in the regression. If such an instrumental variable is available, one can estima9e the causal effect of the explanatory variable ("worry") on the dependent variable ("WTP") even if the explanatory variable is endogenous (Wooldridge, 2002, pp. 83–90). In our study, measures on chronic worry from the worry domains questionnaire (WDQ) turn out to be a valid instrument for worry: first, there is a strong positive and highly significant partial correlation between WDQ and worry (elasticity 0.25; $p < 0.01$, $N = 237$). This is per se an interesting finding because it shows that our worry scores are reasonable; people who tend to worry more in general also tend to be more worried in our experiment (see also the Discussion section). In addition, the WDQ scores are not correlated with the residuals of the regression reported in Table 5 (0.08; $p = 0.17$, $N = 237$). Together, these findings suggest that chronic worry is a reasonable econometric instrument for worry in the experiment. A two-stage Tobit estimation with the WDQ score as an instrument for worry showed that one cannot reject the null hypothesist that worry is an exogenous variable (Wald test $chi^2(1) = 0.56$, $p = 0.46$). Or in other words, we do not find evidence for worry scores being affected by reverse causality.

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DOI: 10.1002/bdm