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Determinants of Priority for Risk Reduction: The Role of Worry

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One hundred twenty-two members (experts) of the Society for Risk Analysis completed a mailed questionnaire and 150 nonexperts completed a similar questionnaire on the World Wide Web. Questions asked included those about priorities on personal and government action for risk reduction, badness of the risk, number of people affected, worry, and probabilities for self and others. Individual differences in mean desire for action were largely explained in terms of worry. Worry, in turn, was largely affected by probability judgments, which were lower for experts than for nonexperts. Differences across risks in the desire for action, within each subject, were also determined largely by worry and probability. Belief in expert knowledge about the risk increased worry and the priority for risk reduction. A second study involving 91 nonexperts (42 interviewed and 49 on the Web) replicated the main findings for nonexperts from the first study. Interviews also probed the determinants of worry, attitudes toward government versus personal control, and protective behaviors.

KEY WORDS: Risk attitudes; worry; emotion; expertise

1. INTRODUCTION

Inspired by Starr's[1] seminal article, researchers have studied the determinants of perceived risk. The resulting "psychometric approach to risk perception" has revealed two things: First, average citizens differ from experts in the determinants of what they consider "risky." Second, citizens' judgments of risk are affected by factors other than the probability and disutility of bad events.[2–4]

Implicit in previous studies is that the term "risk" itself refers to an important precept. This idea—originally found in the literature on risk versus expected return in financial investments[5]—finds clear expression in the work of Fischhoff, Slovic, Lichtenstein, Read, and Combs[6] and more recently in the work of Holtgrave and Weber,[7] who explicitly postulate that perceived risk is a mediating variable for decision making under uncertainty. Much of the work in this tradition has examined the factors influencing risk judgments. Usually risk judgments are predicted by two factors: probability and disutility of the possible outcome. One of these factors can account for much more variance than the other, depending on the person and the kinds of items under discussion.[8–10] Other studies find that risk judgments are affected by other factors—such as catastrophic potential, dread, novelty, naturalness, voluntariness, degree to which risk is unknown, and equity.[8,11–13]

The meaning of "risk," as with other common-language terms, is dependent on the context. Furthermore, the desire to avoid a risk may depend on factors aside from its judged riskiness. It is thus worthwhile to do additional studies, such as this one, that ask people about decisions, even if the choices are hypothetical ones. Subjects were asked about their priority for risk reduction when they could completely eliminate each risk either from their own lives or from the

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lives of average citizens of their country. According to expected-utility theory, this priority should depend on probability and disutility. The subjects were told not to consider cost or the effectiveness of measures designed to reduce each risk.

In the same study, questions were also asked about several determinants of these priority judgments—specifically, probability, disutility ("badness"), and the number of people affected if a bad event occurs. Additionally, questions were asked about two factors that are not considered in a simplistic application of expected-utility theory: how much is known about the risk, and how much the subject worries about it. Previous studies, beginning with Fischhoff *et al.*,[6] have found risk judgments to increase for "unknown risks."

In the present study, the primary interest is the role of worry. Previous researchers have proposed that worry is a determinant of action priority. People may worry about bad events for reasons other than the probability and disutility of those events. Drotz-Sjöberg and Sjöberg,[14] and Sjöberg[15] found that worry about risks was correlated with judgments of riskiness, but they did not examine how worry affected priority. Myers, Henderson-King, and Henderson-King[16] did find that worry was correlated with personal action to reduce risk and with desire for regulation of risk, but they did not ask whether this effect was subsumed by the effects of probability and disutility. Here, the question was whether worry contributes to the prediction of priority for risk reduction even when probability and disutility are taken into account.

Questions about group differences were also explored. Much of the literature on risk perception has been driven by the finding that experts and nonexperts differ in their perceptions.[2] This issue was examined with respect to all the variables of interest: priority for action, probability, disutility, and worry. Also examined were sex differences. Flynn, Slovic, and Mertz[17] found that white women rated risks higher than white men, on a verbal scale. The source of such differences, if found, can be examined.

The next section describes an experiment comparing judgments of experts—defined as members of the Society for Risk Analysis living in the United States—with nonexperts. (Although members of the society are not experts on each risk, it was assumed that they are better informed than the public about risks in general.) The questionnaire for the two groups was identically worded but differed in visual appearance: It was sent by mail to the experts but was completed on the World Wide Web by nonexperts. A second experiment compared responses of nonexperts to a Web questionnaire with responses of nonexperts to a face-to-face interview. In both experiments, worry played an important role in influencing people's decisions on which risks they felt they should protect against, and on which ones the government should reduce.

2. EXPERIMENT 1

The questionnaire in Experiment 1 presented a list of 32 different risks. Each was defined in terms of an outcome and a cause, for example, cancer from electromagnetic fields (EMFs). For each risk, the subject was asked to judge the priority of reducing it for him- or herself and for the country. The subject was also asked the lifetime probability of the bad outcome for the average American family and for his or her own family, the badness (disutility) of that outcome, the number of people affected, the degree of expert knowledge about the risk in question, and how much he or she worries about the risk. Each subject was also asked about the importance of eliminating each risk completely—assuming that this could be accomplished and that cost was not an issue—first with regard to the subject and the subject's family, and then for the American public as a whole.

2.1. Method

Questionnaires were mailed to 312 members of the Society for Risk Analysis; 122 responses were received. These respondents were designated the risk experts. The nonexpert subjects ($n = 150$) completed the questionnaire on the World Wide Web. They found the study through postings in news groups and links from other Web pages, such as that of the American Psychological Society. The two groups differed in a number of socioeconomic dimensions: The experts were older (median age 46 versus 21, range 21–75 versus 16–54), more likely to be male (80% versus 43%), more likely to be married (87% versus 16%), and more likely to have children (72% versus 16%). Age did not correlate with any of the main measures within each group. The groups did not differ, however, on a scale of political liberalism, both being slightly more liberal than "middle of the road" (0.28 and 0.32 on a scale of 3 to −3). All but three of the

Table I. Risks Used in Experiment 1

AIDS
Sexually transmitted
Other causes
Bacterial infections
Contaminated food
Drinking water
Cancer
Chemicals in air
Chemicals in water
Electromagnetic fields
Food additives
Nuclear radiation
Pesticides
Radon gas in homes (lung)
Smoking (lung)
Injury or death
Accidents at home
Accidents at work
Airplane accidents
An asteroid hitting Earth
Auto accidents
Earthquakes
Fire at home
Floods
Hurricanes
Lightning
Terrorism
Tornadoes
Violent crime
War
Other health problems
Air pollution (lung diseases)
Drugs or alcohol
Malnutrition
New diseases (e.g., as ebola)
Unhealthy diet
Vaccines

experts had advanced degrees, 53% having a Ph.D. Of the nonexperts, 76% were students.

After a brief introduction, subjects answered a question for each of the 32 risks shown in Table I and then proceeded to the next question for all the risks until the questionnaire was completed.[2]

All subjects answered the following questions:

1. How much do you worry about each of these risks, on the average, for you and your immediate family? Answer on a scale of 1 to 7, where 1 means "not at all" and 7 means "a great deal." A "great deal" means that you think about it often and that you are greatly bothered by the thought of the bad event in question.

2. Imagine there were a way to completely eliminate some of these risks *to you and your family.* Indicate the priority you would give to eliminating each risk to you and your family. [This is what we call "personal action." The responses were High, Medium, Low, or None, coded as 4, 3, 2, and 1, respectively.]

3. Imagine there were a way to completely eliminate some of these risks *to the American public as a whole.* Indicate the priority you would give to eliminating each risk to the American public as a whole. [This is what we call "government action."]

4. What is the lifetime probability for the *average American family* [4a], and what is the lifetime probability for *you and your family* [4b], for each of the outcomes listed? To answer this question, use the risk ladder on the last page, which may help you in thinking about low probabilities or small proportions. When something can happen more than once, we want the probability that it happens *at least once.*[3]

5. On a scale of 1 to 7, how accurate do you think that experts are in estimating the probability of this outcome for the average person? 7 means extremely accurate. 1 means extremely inaccurate, so that the true probability could be several times more or less than what any given expert thinks.

6. If this outcome happens, how many people, on the average, suffer the *direct* effect at the same time, from the same episode? Answer on the following scale:

1	This happens to one person at a time.
10	More than one person but usually less than 10.
100	More than 10 people but usually less than 100.
1,000	More than 100 people but usually less than 1,000.
More	More than 1,000 people at once.

7. Of those who suffer this effect, how bad, on the average, is the impact *for each person*? Answer on a scale of 0 to 100, where 0 means not bad at all and 100 means as bad as a painful death. (You may go beyond 100 if you need to.)

2.2. Results

Data were analyzed in two ways, by subject, and by item within subjects. Figure 2 shows a schematic layout of the data. Each rectangular plane represents a subject. The four rows in the plane represent the 32 risks. The columns in the plan represent the various measures, the answers to the questions. The dependent variable is designated y, and the predictors a, b, c, and d. For example, the priority for personal action might be the dependent measure y, and might be pre-

[2] There were two exceptions to this principle: the two questions about priority (questions 2 and 3) were on the same page, as were the questions about probability (4a and 4b) and the questions about scope and badness (6 and 7). For these questions, the subject was not discouraged from answering both questions on the page about each risk before going to the next risk.

[3] Figure 1 shows the risk ladder, which was logarthmically spaced. The Web subjects saw only the text, not the vertical line.

Priority for risk reduction

Response	Probability	Example (chance of)
A	1 in 1	Certain to happen
B	1 in 3	A 80 year old dying by 85
C	1 in 10	A 65 year old dying by 70
D	1 in 30	A 51 year old dying by 56
E	1 in 100	A 35 year old dying by 40
F	1 in 300	A 20 year old dying by 23
G	1 in 1,000	A 20 year old dying in the next year
H	1 in 3,000	A 20 year old dying in the next 4 months
I	1 in 10,000	A 20 year old dying in the next 5 weeks
J	1 in 30,000	A 20 year old dying in the next 2 weeks
K	1 in 100,000	A 20 year old dying in the next 4 days
L	less than 1 in 100,000	(specify the probability)

Fig. 1. Risk ladder used for experts in Experiment 1 and interviewed subjects in Experiment 2.

dicted from worry, personal probability (expressed logarithmically), badness, and knowledge. Each variable has two subscripts. The first refers to the subject and the second to the risk. At the bottom of each column are variables representing the mean response of a given subject, for example, $a_{1.}$ for the first subject's answer to the first predictor.

In one type of analysis, only the subject's marginal means were considered—the values at the bottom of each rectangle. These means, $y_{..}$ were regressed against the means of the predictors, $a_{..}, b_{..}, \ldots$, but only these means were used. The individual items are relevant only because they contribute to each subject's average. This kind of analysis is relevant to questions about individual differences among subjects. Other subject characteristics can also be used as predictors in this kind of analysis, such as sex, age, and expertise.

In the other type of analysis, a regression is carried out within each subject. The y's are predicted

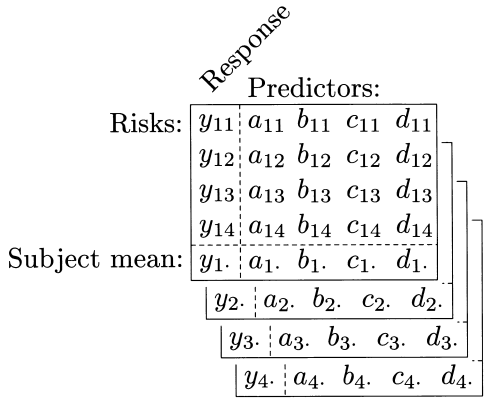

Fig. 2. Schematic illustration of the structure of the data. The first subscript refers to subject, the second to risk items.

from the various predictors, and a regression weight is found for each predictor, for each subject. To test statistical significance, these regression weights are treated as the primary data, and questions are asked about their mean value across subjects.

2.2.1. Individual and Group Differences in Determinants of Mean Responses

Each subject's mean response to each question was calculated, across the 32 risks. These means allow for asking whether the general tendency of people to support action, to worry, and to assign high probabilities to bad events are related to sex, expertise, politics, age, marriage, and parenthood. Of primary interest are the effects of expertise and sex, but, as noted earlier, expertise was correlated with other variables, including sex. Multiple linear regression was therefore used as the primary method of analysis.

Table II shows the main results. Table IIA shows the means of the main measures for the two groups. Table IIB shows the regressions of government and personal action, probability, and worry on expertise, age, sex, marriage, parenthood, and political liberalism. Table IIC shows regressions of government and personal action and worry on probability, and the three most important demographic variables: expertise, liberalism, and sex (coded 1 for males, 0 for females).[4] In this part of the table, regressions of worry are included

[4] We did not include badness because we had asked subjects to evaluate badness relative to death, so it is difficult to know how to interpret individual differences in the mean badness rating across risks. We did not include knowledge in the regressions in the tables because it was not significant in any regression. We omitted age, marriage, and parenthood because they did not play a major role in the regressions in Table II.

Table II. Mean Responses of Experts and Nonexpert to Questions About Risk and Standardized Regression Weights for Predictors of Individual and Group Differences in Experiment 1

A. Means of experts and nonexperts

Question (range)	Expert mean	Nonexpert mean
Personal action (1–4)	2.45	2.76
Government action (1–4)	2.82	3.12
Worry (1–7)	2.45	2.71
Personal risk (log prob.)	−5.53	−4.04
Average risk (log prob.)	−4.80	−3.42
Certainty (1–7)	4.71	4.53

B. Standardized regression weights: demographic variables only

	Dependent variable				
Predictor	Personal action	Government action	Personal problem	Average problem	Worry
Expert	−0.35**	−0.41**	−0.54**	−0.53**	−0.16
Liberal	0.15*	0.20**	0.06	0.07	0.05
Sex	−0.07	−0.18**	0.05	−0.01	−0.03
Age	0.09	0.05	0.15	0.06	0.02
Parenthood	−0.07	−0.02	0.04	0.03	−0.03
Married	0.07	0.19*	−0.16	−0.06	0.04
R^2	0.12**	0.18**	0.26**	0.27**	0.02

C. Standardized regression weights: main demographic variables, probability, and worry

	Dependent variable					
Predictor	Personal action	Personal action	Worry	Government action	Government action	Worry
Worry		0.42**			0.27**	
Personal probability	0.15*	0.08	0.17*			
Average probability				0.28**	0.22**	0.20**
Expert	−0.20**	−0.18**	−0.05	−0.12	−0.11	−0.04
Liberal	0.14*	0.13*	0.05	0.17**	0.15**	0.05
Sex	−0.06	−0.05	−0.02	−0.16**	−0.15**	−0.01
R^2	0.14**	0.30	0.05*	0.29**	0.22**	0.05*

Note: $N \approx 265$, sex is coded as 1 for male, 0 for female. Probability is coded logarithmically.
* $p < 0.05$; ** $p < 0.01$.

on the other variables. These regressions are relevant to questions about the mediating role of worry.

Probabilities were coded logarithmically, with two steps on the ladder corresponding to one unit. (Probabilities below 10^{-10} were set at 10^{-10}.)

Experts were less supportive of personal action and government action than nonexperts (Table IIA and IIB). The mean rating for personal action was lower for experts (mean, adjusted for sex, is 2.48 on a scale where high priority is 4 and no priority is 1) than nonexperts (mean, 2.75). Likewise, the mean rating for government action was lower for experts than nonexperts (2.85 versus 3.11, adjusted for sex). Experts also gave much lower probabilities than nonexperts (means, −5.53 versus −4.04 for own risk, $t = 8.65$; −4.80 versus −3.24 for average log probability, $t = 9.04$). One possible explanation of this difference is that experts are more willing to use the bottom of the scale (shown in Fig. 1) to indicate low probabilities, rather than there being a real difference in belief.

Females supported government action more than males (3.06 versus 2.95, adjusted for expertise).[5]

[5] Although sex had no significant effect on personal action, its effect was in the same direction and the predictors of the two types of action were not significantly different (in a canonical correlation).

Support of both personal and government action correlated positively with political liberalism. Both of these effects may be related to political attitudes more than to beliefs about probability. Sex and liberalism were unrelated to beliefs about probability.

Table IIC shows that worry is strongly related to personal and government action. Probability also affects action, but the effect of personal probability on personal action (and, to a lesser extent, on government action) is reduced when worry is included in the regression equation (second column compared to first column, and fourth compared to third). These results suggest a model in which worry mediates the effect of probability on tendency for personal or government action. To test this model, two new variables were formed for each subject: probability—the mean of personal and average probability—and action—the mean of personal and government action. These two variables were regressed on sex, expertise, and liberalism and the residuals were calculated. This procedure was repeated, with mean worry added as a predictor. Consistent with the hypothesis that worry mediates the correlation between action and probability, it was found that the correlation between the residuals was smaller when worry was included as a predictor (0.1490) than when it was not (0.2091). As these are dependent correlations, their difference was tested with the method proposed by Steiger;[18] a z of 2.207 ($p = 0.0137$) was found.

In sum, the correlation between probability and action is significantly reduced when the correlation of each of these variables with worry is taken into account. It appears that worry mediates the correlation between tendency to action and probability. Most likely, the perception that risk is great induces worry, which, in turn, creates a positive attitude toward action. It is also possible that worry is induced directly by some other factor—such as personal experience or exposure to news reports—and that worry affects probability judgments, or that the other factors affect both worry and probability judgments.

Subjects thought, in general, that their own probabilities of bad events were lower than the average probabilities (mean, −4.70 for own risks, −4.03 for average on a base-10 logarithmic scale, a ratio of more than 4; $t = 13.50$, $p = 0.000$). This may, of course, be true, as the groups were unrepresentative of the U.S. population, but it could also result from an optimistic bias (Weinstein, 2000).[19]

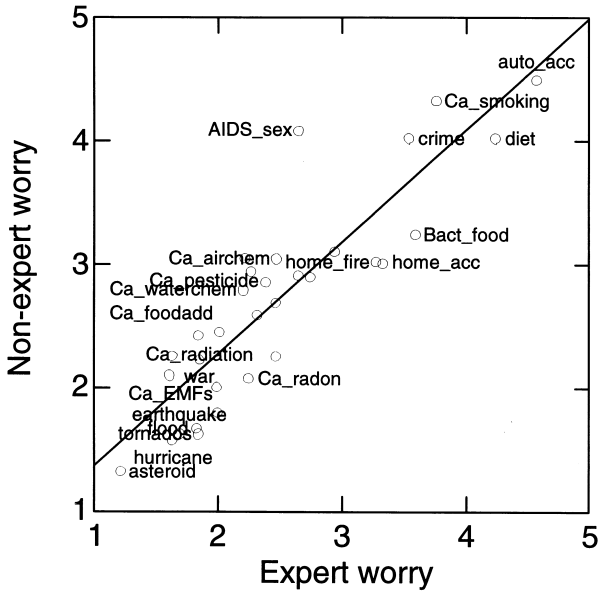

Fig. 3. Mean worry ratings of experts as a function of the corresponding means for nonexperts. Each point is one of the 32 risks, those starting with "Ca" are cancer risks. Some labels are omitted.

2.2.2. *Individual Differences Concerning Particular Risks*

In this section, the determinants of the pattern of responses across the 32 risks is examined. In particular, of interest is whether experts and nonexperts differ in which risks they rate high on each scale and which they rate low. Such differences have been reported before,[2] but the sample of risks here includes some that are current sources of public controversy.

Experts and nonexperts differed in the risks they worried about. The interaction between expertise and risk was significant, $F(31, 7967) = 6.41, p = 0.0000$). Figure 3 plots mean expert worry against mean nonexpert worry. Group differences were examined by looking at correlations between expertise and worry for each of the 32 risks. The four highest correlations (indicating that experts worry more) were with bacteria from food, lightning, fire at home, and accidents at home. The four lowest correlations (all negative) were AIDS from sex, AIDS from other causes, malnutrition, and cancer from chemicals in water. Some of these differences may reflect the fact that experts were older and more settled, hence less exposed to the risk of AIDS, for example. But the expertise-risk interaction was still significant when marital status and age were statistically controlled. The four risks that experts worried relatively most about were radon gas, unhealthy diet, drugs or alcohol, and accidents at

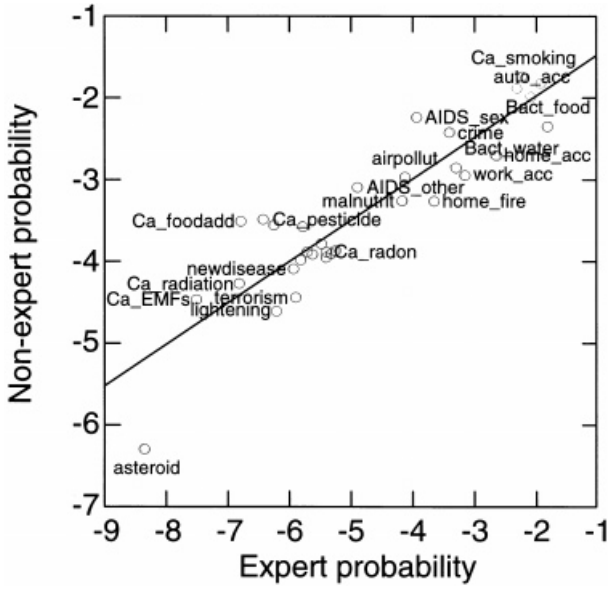

Fig. 4. Mean log probability judgments of experts (for average family) as a function of the corresponding means for nonexperts. Each point is one of the 32 risks, those starting with "Ca" are cancer risks. Some labels are omitted.

home. The four risks that experts worried relatively least about were cancer from pesticides, AIDS (both causes), and accidents at work. These low ratings could result either from greater knowledge or from less exposure to each risk.

Figure 4 shows the mean (logged) average-family probability judgments of experts plotted against those of nonexperts. Experts gave lower probabilities than nonexperts. To determine whether these differences were statistically meaningful, each subject's (logged) probability estimates were standardized across the 32 risks (replacing missing data with the mean standardized score across all subjects). This standardization yielded probabilities comparing other risks rated by the same subject. An analysis of variance showed a significant interaction between risk and expertise, $F(31, 7812) = 10.66, p = 0.0000$. That is, experts' standardized probabilities were higher for some risks than nonexperts, and lower for others. Age, sex, liberalism, and marital status did not interact significantly with risk when added to the regression. Thus, expertise seems to be the main determinant on the pattern of beliefs about probability of risk.

Experts had "significantly" higher probabilities than nonexperts ($p < 0.05$ uncorrected, with correlations between log probability and expertise [coded 1 or 0] in parentheses) for bacterial infections from food (0.29), infections from water (0.15), unhealthy diet (0.15), fires at home (0.28), accidents at home (0.24), accidents at work (0.21), and auto accidents (0.19). Experts had significantly lower probabilities for cancer from food additives (−0.44), cancer from pesticides (−0.40), cancer from chemicals in water (−0.34), cancer from chemicals in air (−0.20), cancer from EMFs (−0.29), cancer from nuclear radiation (−0.22), AIDS from sex (−0.22), and AIDS from other causes (−0.14). Note that these "probabilities" are relative to each subject's other judgments, so they reflect the ranking of risks relative to other risks. A similar pattern of expert/nonexpert differences was found (but not reported here) in support of government action. It is possible that nonexperts are more influenced by coverage in news media and experts are more influenced by statistical data. News reports may concentrate disproportionately on low risks of cancer.

2.2.3. Individual Differences in Within-Subject Effects

Correlational analyses were carried out across the 32 risks within each subject. Table III shows the means, across subjects, of these within-subject correlations between measures across the 32 risks. Of interest here is that worry was more highly correlated with personal action than with government action

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Table III. Mean Within-Subject Correlations, Across Risks, in Experiment 1

	Worry	Personal action	Government action	Personal risk	Average risk	Certainty	Scope
Personal action	0.6443						
Government action	0.4555	0.6187					
Personal risk	0.4906	0.4916	0.3707				
Average risk	0.4474	0.4462	0.4608	0.6688			
Certainty	0.1363	0.1326	0.1767	0.1587	0.2404		
Scope	−0.0633	−0.0625	0.0206	−0.0779	−0.0827	−0.0462	
Badness	0.0492	0.0835	0.1113	−0.1311	−0.1175	−0.0007	0.0581

Table IV. Mean Within-Subject, Standardized, Regression Weights

	Dependent variable				
Predictor	Personal action	Personal action	Government action	Government action	Worry
Worry	0.475		0.252		
Personal probability	0.248	0.493			0.490
Average probability			0.304	0.416	
Badness	0.098	0.166	0.131	0.162	0.120
Certainty	0.032	0.058	0.076	0.085	0.057
Scope[a]	(−0.003)	(−0.028)	0.118	0.101	(−0.028)

[a] Parentheses indicate not significant at $p < 0.05$.

($t = 15.66$, $p = 0.0000$, across subjects), and more highly correlated with personal probability than with average probability ($t = 3.02$, $p = 0.0028$). Personal action is more highly correlated with personal probability than with average probability ($t = 3.38$, $p = 0.0008$), and government action is more highly correlated with average probability than with personal probability ($t = 6.89$, $p = 0.0000$). These results are not unexpected; people worry about risks that affect them and want to take personal actions that reduce their own risks. The demand for action taken by the government is more likely to be triggered by the estimate of risk to the average American family.

The determinants of worry, priority for government action, and priority for personal action were analyzed for each subject. To do this, each of these measures was regressed on predictor variables—such as judged probability of a bad event—within each subject, across the 32 risks. The coefficients indicate what accounts for differences in each subject's worry and priorities. What makes a subject more inclined to take action for some risks than for others? What makes him or her worry more about some risks than others? Note that this question is independent of that already asked, which concerns the mean tendency to act or to worry, across many different risks.

Personal action was regressed on personal probability, badness, certainty (expert knowledge about probability), and scope (number of people affected), with and without worry as an additional predictor. Government action was also regressed on average probability, badness, certainty, and scope, again with and without worry.

Table IV shows the mean standardized regression coefficients, which allow comparison of effect sizes. Of interest is the fact that probabilities were strong predictors of all dependent measures, stronger even than badness ratings. Support for action was higher when the subject thought that experts knew more about the probability of the risk, a result opposite that of Slovic.[2] Finally, scope (number of people affected) predicted government action but not personal action; this result is, in a way, a manipulation check. If individuals are concerned mainly about themselves and their families, then scope should have little effect, but it should matter for government policy.

As in the analysis of means, worry was a strong predictor of support for action, especially personal action, and probability was a strong predictor of worry. Regression weights were compared using standardized coefficients (shown in Table IV). To test the mediating role of worry, the mean coefficients of personal probability were compared for predicting personal action, with and without worry in the model. When worry was included, the coefficient for probability was much lower (0.248 versus 0.493; $t_{239} = 14.09$, $p = 0.0000$). Likewise, the coefficient for average probability for predicting government action was lower when worry was included ($t_{237} = 9.15$, $p = 0.0000$). It appears that probability beliefs affect support for action toward particular risks in part because they are related to worry about these risks. (Again, the causal direction of this relation may be bidirectional. Worrying about a risk may lead people to exaggerate its probability, relative to other risks.)

The effect of worry was greater on personal action (0.310) than on government action (0.147, $p = 0.0000$ by t test across subjects). In a separate analysis in which worry was regressed on personal and average probability together (and on the other three predictors), the coefficient for personal probability (0.358) was higher than that for average probability (0.143, $p = 0.0012$). Thus, the main role of worry is in mediating personal action, and the main determinant of worry is personal probability, although worry also plays some role in government action and is somewhat influenced by average probability.

Scope affected government action but not per-

sonal action, although badness affected both. The difference in the two scope coefficients was significant ($t = 4.26$, $p = 0.0000$ in the regressions without worry). This suggests that subjects understood that scope is most relevant for government action rather than personal action.

Also examined was the effect of sex, expertise, and liberalism on the regression weights. Again, because expertise and sex were confounded, multiple regression was used. Such analyses reveal how people differ in what determines their support for action or their worry.

In personal action, men were more influenced by worry (0.068 for the unstandardized coefficient of the worry coefficient for sex, $p = 0.0354$; this result does not imply that men worry more then women, and it is consistent with the present finding that they do *not* do so). None of the remaining coefficients (in the regression with worry removed) showed any significant effects of sex, liberalism, or expertise. For government action, no predictors were significant.

The largest individual differences were found in the determinants of worry. Worry in women was more affected by personal probability than worry in men (0.154, $p = 0.0031$). Worry in nonexperts was also somewhat more influenced by personal probability than worry in experts (0.104, $p = 0.044$).

In sum, despite the large differences in age, expertise, and other variables between experts and subjects questioned on the Web, the within-subject determinants of action and worry were much the same for both groups. Men's personal action was more affected by worry than women's, and women's worry was more affected by personal probability than men's, but these effects are post hoc. The main finding here is that, while groups differ in mean levels of tendency to action and worry, they do not differ much in how they respond to different risks.

3. EXPERIMENT 2

Experiment 2 attempted to replicate the major findings of Experiment 1 while serving two additional purposes. First, it compared two groups of nonexpert subjects, one group completing the questionnaire in personal interviews and the other completing the same questionnaire on the Web. This permitted a more direct comparison of these two methods.

Second, the interview subjects, after completing the questionnaire, were asked to explain the reasons for discrepancies in their answers.

3.1 Method

Forty-nine subjects completed a similar questionnaire to that of Experiment 1 on the Web. The only substantive difference was in the questions about action to reduce the risk, where there was no indication that the risk could be completely reduced. These questions were worded as follows:

> If you had more money to spend, which of these risks would you spend it on? Circle the priority you would give to each risk: Hi = high, Med = medium, Lo = low, No = no money at all. [Note: Of interest was all expenditures in advance, whether they reduce the probability or magnitude.]
>
> If the government had more money to spend, which of these risks would you like the government to spend it on? Circle the priority you would give to each risk: Hi = high, Med = medium, Lo = low, No = no money at all.

Forty-two others completed the same questionnaire doing a one-on-one interview. The interviewer answered the subjects' questions, checked the answers for completeness, and asked a series of follow-up questions. Interview subjects were limited to those living on their own (i.e., not in university residences or with their parents) because the follow-up questions concerned protective behaviors that would be relevant only for such people. A varied sample was used, including people living near the University of Pennsylvania, in West Philadelphia, a community consisting of students, university staff, and a variety of ethnic groups. The Web subjects were similar to those in Experiment 1. Web subjects were younger than those who had interviews (median age, 19 versus 30.5, range 18–47 versus 18–81, $p = 0.0000$ by U test), had fewer children (mean 0.3 and 0.8, respectively; $p = 0.0011$ by U test), were more likely to be students (92% versus 45%, $p = 0.0000$ by Fisher test), but were no different in sex (29% male versus 36%) or politics (mean, 2.8 versus 2.6, respectively, on a 5-point scale of liberalism).

Twenty-eight of the interview subjects were contacted for follow-up interviews. These interviews were concerned with two issues. The first was the difference between worry and expected disutility (probability $\times$ badness). We wanted to know why people worry about risks that they perceive as not bad or not very probable, and why they fail to worry about risks that they perceive as likely and serious. Risks that were ranked high in worry and low in expected disutility, and vice versa, especially were looked for. Four risks for the worry versus expected-disutility question were selected as follows: the probability was multiplied by the badness rating for each risk and the resulting expected-

disutility estimates were ranked; the worry ratings were also ranked; and the ranks were subtracted, with the two highest and two lowest (most negative) differences selected for follow-up questioning (with arbitrary choices made in the case of ties).

The second issue concerned the difference between personal and government responsibility for risk reduction. The interviewer (arbitrarily) selected two of the risks with the greatest discrepancy favoring government action, and two with the greatest discrepancy favoring personal action.

3.2 Results

3.2.1. Group and Demographic Differences in Determinants of Mean Responses

As in Experiment 1, subjects' mean responses to each question were calculated across all 32 risks. It was first determined whether Web subjects differed from interview subjects—a question of methodological interest.[20] In an analysis of variance of the means of all major variables (government concern, personal concern, worry, knowledge, badness, average probability, personal probability, and scope—the number of people affected), the effect of group (Web versus interview) was significant overall, $F(8,83) = 3.16, p = 0.0036$, but the only variable that showed a significant effect was average probability, which was higher in the Web group (mean log, −3.49 for interview, −3.13 for Web; $t = 2.39$, $p = 0.0188$). The interaction between Web versus interview and average versus personal probability was also significant, $F(1,90) = 6.12$, $p = 0.0153$, indicating the difference is specific to average probability. The overall analysis was no longer significant when average probability was removed.

One explanation of the difference is the format of the two questionnaires. On the Web, subjects answered questions about average probability first, and then questions about personal probability. In the interview, the two questions were presented side by side, a format that may have encouraged subjects to give the same answer to both questions. Of course, this explains only the interaction and not the fact that average probability was higher for subjects on the Web, which may have to do with the format of the risk ladder: all text on the Web but with a visual display in the interview. It is encouraging that other variables did not differ. In sum, the differences between Web and interview responses are easily understood in terms of display factors.

Other determinants of mean responses were also examined: age, sex, student status, politics, and children. A canonical correlation analysis suggested that a single dimension of individual differences accounted for differences in worry, probability, badness, scope, and certainty ($p = 0.0174$ for the entire analysis), and that worry was the main variable that captured these effects. Separate regression analyses confirmed that only worry showed significant effects. In particular, mean worry increased with number of children ($t = 2.84$, $p = 0.0057$, for the regression coefficient) and decreased with being married ($t = 2.05$, $p = 0.0436$). In sum, the ones who worry the least are those who are married but childless.

Separate analyses in which Black, compared to White—excluding other groups, was differentiated also found that blacks worried more than whites ($t = 3.52$, $p = 0.0010$). There was no difference between Asians and whites, however, and men and women did not differ in this study.

3.2.2. Determinants of Mean Personal and Government Action

Separate regression analyses predicting individual differences in personal and government action from worry, badness, certainty, scope, and probability (personal probability for personal action, average probability for government action) were significant ($R^2 = 0.27$ and 0.36, respectively; $p = 0.0000$ for both). The only significant predictor was worry ($t = 4.37$ and 5.45, respectively; $p = 0.0000$ for both), except that scope was significant one-tailed for government action ($t = 1.77, p = 0.0405$).[6] In all the regressions reported below, an effect of group (interview versus Web) was analyzed by comparing the standardized coefficients. In no analysis was there any significant effect. Thus, predictability of mean responses appears similar for Web and interview subjects.

3.2.3. Determinants of Mean Worry

Worry itself was predicted by average probability ($t = 2.12, p = 0.0366$), but not by personal proba-

[6] Because worry may mediate the effects of other factors, we removed worry from the regression to examine the effects of these factors. When worry was removed, the overall regressions were still significant for government action ($R^2 = 0.14, p = 0.0099$) and for personal action ($R^2 = 0.11, p = 0.0316$). For government action, significant predictors were average probability ($t = 2.79, p = 0.0065$) and scope ($t = 1.90, p = 0.0302$ one tailed). For personal action, the only significant predictors were personal probability ($t = 1.89, p = 0.0312$ one tailed) and (inexplicably) scope ($t = 1.88, p = 0.0321$ one tailed). Note that we are talking here about indiviual differences among subjects in the mean ratings, not differences among the risks.

Table V. Mean Within-Subject Correlations, Across Risks, in Experiment 2

	Worry	Personal action	Government action	Personal risk	Average risk	Certainty	Scope
Personal action	0.5768						
Government action	0.3663	0.4861					
Personal risk	0.4546	0.4066	0.2786				
Average risk	0.4198	0.4095	0.3209	0.6448			
Certainty	0.1557	0.1818	0.1102	0.1316	0.2118		
Scope	−0.0460	−0.0157	0.1430	−0.0423	−0.0165	0.0646	
Badness	0.1411	0.1274	0.1456	−0.0408	−0.0200	0.0237	0.1496

bility in a regression on both. When it was regressed on average probability, badness, knowledge, and scope, the overall regression was significant (R^2 = 0.10, p = 0.0482) and the only significant predictor was average probability (t = 2.77, p = 0.0069).

In sum, it appears that individual differences in desire for action are determined largely by differences in worry, which, in turn, are determined primarily by differences in probabilities, a finding similar to that of Experiment 1.

3.2.4. Determinants of Mean Probability Judgments

As in Experiment 1, the logarithmic scale for probabilities was used and results are reported that way. Subjects believed, as in Experiment 1, that their own risks were lower than average (mean, −3.91 for own risks, −3.30 for average, a ratio of more than 4; t = 9.67, p = 0.0000).

3.2.5. Individual Differences in Within-Subject Effects

Table V shows the mean within-subject correlations between measures across the 32 risks. Of interest here is that worry was more highly correlated with personal action than with government action (t = 8.64, p = 0.0000, across subjects), and more highly correlated with personal probability than with average probability (t = 1.89, p = 0.0309, one-tailed). Worry thus seems more important for personal risks than for societal risks. In contrast to Experiment 1, men and women did not differ in the correlation between personal action and worry.

The determinants of responses for each subject were analyzed by regressing each dependent measure on the predictor measures and examining the regression coefficients. Personal action on personal probability, badness, certainty, and scope were regressed, with and without worry as an additional predictor. Also regressed was government action on average probability, badness, certainty, and scope, again with and without worry. Finally, worry was regressed on personal probability, badness, certainty, and scope.

Table VI shows the mean standardized regression coefficients. Of interest is the fact that probabilities were strong predictors of all dependent measures, even stronger than badness ratings. Tendency for personal action was higher when subjects thought that experts were more certain about the probability of the risk. Finally, scope predicted government action but not personal action (again, suggesting that subjects understood that scope is more relevant to government action).

Table VI. Mean Within-Subject, Standardized, Regression Weights

	Dependent variable				
Predictor	Personal action	Personal action	Government action	Government action	Worry
Worry	0.444		0.256		
Personal probability	0.134	0.325			0.428
Average probability			0.179	0.300	
Badness	0.051	0.107	0.068	0.102	0.147
Certainty	0.083	0.139	(0.008)	(0.030)	0.107
Scope[a]	(0.004)	(0.004)	0.150	0.125	(−0.023)

[a] Parentheses indicate not significant at $p < 0.05$.

As in the analysis of means, worry was a strong predictor of tendency to action, especially personal action, and probability was a strong predictor of worry.

Scope affected government action but not personal action, although badness affected both. The difference in the two scope coefficients was significant ($t = 2.82$, $p = 0.0059$ in the regressions without worry). This suggests that subjects took the distinction seriously.

3.2.6. Follow-up Interview

To examine expected disutility versus worry, the follow-up interview included the following questions:

> Where have you heard about this risk? Do you know people who have experienced it? Have you heard about it in the news? In movies or TV shows?
>
> Do you remember hearing or reading any statistical information about this risk?
>
> Why do you worry (not worry) about this risk?

Almost all subjects mentioned news or TV as the source for every risk. A difference between worrisome and nonworrisome risks, in terms of personal experience and knowledge of statistics, was looked for. It was expected that people would worry more when they have personal experience (or know someone who had such experience). The relation between recalling statistics and worry could go either way. People might worry more about risks that they have heard more about, or find their worries allayed by statistical information. In fact, both responses were more frequent for worrisome risks. Subjects mentioned statistics for 52% of the most worrisome risks but only for 32% of the least worrisome risks ($z = 2.52$, $p = 0.0116$, Wilcoxon test). And they said they had knowledge of personal experience for 40% of the most worrisome risks but only 31% of the least worrisome risks ($z = 2.06$, $p = 0.0397$).

In response to the questions about reasons for worry (or not), Table VII shows the percent of subjects giving each of several reasons for worrying or not worrying.

Personal control was mainly given as a justification for not worrying. The implication is that the person had, in fact, taken steps to control the risk. Only one person (4%) gave control as a reason for worry. Control *could* be a reason for worry, if worry functions as a way of motivating people to remember to take protective action. Others (21%) worried about risks because they could not control them, for example, they worried about auto accidents caused by other drivers.

Table VII. Percent of Responses to Worrying or Not Worrying About Risk Factors

Reason	Worry	Not worry
Personal control	4	32
Lack of personal control	21	25
Government control or lack	7	7
Lack of knowledge	11	0
Probability overall	29	18
Probability for self	18	64
Bad or not bad	36	11
Social problem	11	0
Personal experience	21	0

Note: $N = 28$.

Such worry could also help people remember to take protective action if the lack of control is only partial. For example, people who think they cannot control automobile accidents may still think that they can protect themselves by wearing seat belts. The third category—Government control or lack—involved giving lack of government control as a reason for worry (analogous to lack of personal control), or the presence of adequate government control as a reason for not worrying. For example, one subject worried about new diseases because "World Health people are behind and strains become immune and we could be heading back to the days of epidemics because the World Health can't keep up with all the different strains."

The association between lack of knowledge and worry refers more to lack of personal knowledge than to beliefs about what the experts know. One subject worried about EMFs because "it is something people talk about but I don't really understand it." Thus, the prevalence of this response as a reason for worry is not inconsistent with the finding that expert knowledge was, if anything, positively related to worry.

People gave average probability as a reason for worry, but they often justified not worrying in terms of their own perceived low probability, for example, not being in a high-risk area for natural disasters or not engaging in behaviors that could lead to AIDS. Badness of the outcome was also given as a reason for worry, as was the statement that something was a "big problem for society" (AIDS or drugs).

Personal experience was the item most consistently associated with worry about risks that were relatively low in expected disutility. For example, one woman worried about air pollution because her husband had asthma, and a man worried about it because his father died of lung cancer.

Concerning risks with disagreement between

what government should do and what individuals should do, the interview asked:

> Why do you think that government should (should not) try to reduce this risk?
>
> How much do you think that individuals can reduce the probability and magnitude of this risk?
>
> How much do you think that government can reduce the probability and magnitude of this risk?

It was difficult to find risks in both categories for everyone, since the sample tended to strongly favor government responsibility. (Although predominantly "middle of the road" politically, most subjects who were residents of West Philadelphia, both students and nonstudents, tend to vote Democrat and favor government action.) Still, risks could be roughly classified in terms of attitudes about who should control them. Not all the risks in the study were classified, each subject was asked about only four. Attitudes toward who should reduce the risk were most strongly justified in terms of who could control it most easily.

The largest category included risks that subjects felt should be dealt with by government because the government could control them and individuals could not: pesticides, cancer from food additives, contaminated food, vaccines, new diseases, AIDS from causes other than sex, chemicals in air and water, air pollution, nuclear radiation, airplane accidents, floods, war, and asteroids.

A few risks followed the opposite pattern, with respondents feeling that government should play a lesser role in reducing the risks because individuals had more control over them than government: fires and accidents in the home, unhealthy diet, lightning, and tornadoes. For these risks, subjects tended to say that individuals were "responsible" for their control as well as that they could control the risk more easily.

For other risks, subjects said that both the government and the individual could control the risk, and, in these cases, they typically said that the government *should* control it: auto accidents, drugs/alcohol, AIDS from sex, and hurricanes. For example, individuals can drive safely, but government should enforce speed limits. In response to the question about why government should control the risk, many respondents referred to the seriousness of the risk rather than the relative ease of control (e.g., "There is too much drunk driving and it destroys family life").

Some risks fell into a mixed category, with subjects providing varied responses: crime, accidents at work, radon gas, earthquakes (some respondents said that nobody could do anything for this particular risk). For example, two subjects said that the government can educate people about radon, but another said that the government cannot do much and that this risk is up to homeowners to alleviate.

It is interesting that, for almost every risk, one could argue that both the individual and the government could do something. This is particularly true when individual actions such as voting and giving money to causes are counted —as some subjects explicitly did for malnutrition and war—and when education of individuals is viewed as a function of government—as subjects did for unhealthy diet and radon. Yet despite this possibility, 38% of the answers indicated that the individual and government had little or no control over the risk. In general, subjects seemed unaware of some of the possibilities for both the individual and the government to take action to reduce risks.

The last question asked what protective behaviors the subject took, and, in particular, why he or she did not do anything to prevent risks with the highest expected disutility, and why he or she did take action to protect against those with the lowest. Selection of risks for this question was not, however, systematic, and subjects tended to answer about risks discussed in other parts of the interview.

Two subjects said they did not protect against any of the risks. Other subjects mentioned a variety of protective actions, for example, avoiding fast-food restaurants and pesticides, boiling water, using condoms, and getting a smoke detector. Subjects also mentioned not taking any protective actions against certain risks because they thought that these actions were unnecessary, ineffective, or both. These included hurricanes, war, and bacterial infections and accidents at work. One subject did not want to protect against cancer from food additives because "I don't know what to do and don't want to give up foods I like, just in case." Another subject thought that protection against asteroids was unnecessary "because if they hit it is more likely they'll hit in a cornfield than in a city."

4. CONCLUSION

A major finding of these two experiments is that concern for action, both personal and government, is strongly related to worry. Worry, in turn, is affected mainly by beliefs about probability. Although a comparison was not made of the risk ladder used in the present study to other methods, the strength of the probability effect suggests that this method is effective

for eliciting probability judgments. It certainly did allow for a wide range of responses. (Eiser & Hoepfner [21] discuss the effects of response options on probability judgment.)

The relatively small effect of badness, on the other hand, may result from the choice of risks to include in the questionnaire. Most of the risks cited were serious ones. In a regression model, the weight of this dimension would be determined by even a few cases in which the risks were not so bad (e.g., bacterial infections), but range of variation in probability may still have been greater (in logarithmic terms) than the range of variation in badness of outcomes. The small effect may also result from the way questions were asked. Other researchers have found larger effects in similar studies.[19]

Experts and nonexperts did not differ much in what determined their worries or their desire for action, but they did differ in their beliefs about particular risks. Nonexperts were much more concerned about what experts consider to be small risks of cancer from environmental sources. Experts were more concerned about the statistically more frequent, but more mundane, events such as auto accidents. These differences may result from attention in news reporting, with nonexperts being more influenced by this source. This is, of course, what was found by Lichtenstein et al.,[22] but the particular risks subject to public concern may have changed in the last 20 years.

The direction of causality between worry and beliefs about probability was uncertain. Possibly people inflate their probability estimates of risks they worry about in order to make their worry seem rationally justified. If, however, probability beliefs affect worry, then it may be possible to change what people worry about by providing them with more accurate and comparative information about probabilities. If worry then affects protective behavior and political action, then people may engage in more effective protective behavior, and they may support the efforts of government to reduce more serious risks. The interview study supported the relation between worry and perceived probability. In addition, worry was sometimes related to control and sometimes to lack thereof. If worry is a determining factor in people's attitudes toward certain risks, then it may be helpful to provide individuals with information about actions that are now being taken by industry and government as well as what they themselves can do to reduce either the likelihood or consequences of future events.

In conclusion, even though worry is an unpleasant emotion, it may be important in moving people to protect themselves against harm, both individually and collectively. More research is needed to better understand the role that worry plays in people's perception of risk and the actions that they take to reduce their future losses. In particular, although worry may motivate protective action, it may also be somewhat autonomous from beliefs. People may worry too much about risks they know to be minor and too little about risks they know to be serious.[23] This discrepancy may weaken the effectiveness of attempts to inform people about the relative probability of risks. If so, it might be fruitful to try to address the worry itself.

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