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Risk Communication: Absolute versus Relative Expressions of Low-Probability Risks

ERIC R. STONE, J. FRANK YATES, AND ANDREW M. PARKER

University of Michigan

According to most prescriptive decision rules, formally equivalent methods of communicating risk information should have identical effects on risk-taking behavior, even if the pertinent displays are different. The present work takes two methods commonly employed in epidemiology, incidence rates and relative risks, and examines their comparative effects on risk-avoidant behavior. In Experiment 1, we presented 108 undergraduates with information about risks associated with different brands of tires and toothpaste and displayed that information either as incidence rates or as a relative risk ratio. For the tires product, subjects given the relative risk format were willing to pay more money for a safer product than were subjects given the incidence rate format. There were, however, no differences between the two conditions for the toothpaste product. Experiment 2 evaluated two potential explanations for the difference in findings between the two products. The majority of the data supported an "editing" hypothesis, which suggests that extreme low-probability risks, such as those associated with tire blowouts, are edited to "essentially nil risk," while more moderate risks, such as those associated with periodontal disease, are considered to be small but significant. These findings are discussed in the context of fuzzy trace theory and related models, which suggest that people reason on the basis of simplified representations rather than on the literal information available.

The way in which information is presented, or framed, influences how it is perceived and used (e.g., Tversky & Kahneman, 1981). In one widely cited study, subjects were told either that the chance of experiencing at least one disabling injury when driving without a seatbelt is .00001 for each trip, or that the probability is .33 over 50 years of driving. These statistics are formally equivalent given reasonable assumptions, but subjects in the latter condition were much more likely to say that they would wear seatbelts in the future (Slovic, Fischhoff, & Lichtenstein, 1978).

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Eric Stone is currently affiliated with Wake Forest University, and Andrew Parker is a graduate student at Carnegie-Mellon University. Correspondence and reprint requests should be addressed to Eric R. Stone, Department of Psychology, Wake Forest University, Box 7778, Winston-Salem, NC 27109, or to J. Frank Yates, Judgment and Decision Laboratory, Department of Psychology, University of Michigan, 330 Packard Road, Ann Arbor, MI 48104-2994.

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This type of result has led researchers to suggest that people are, to some extent, at the mercy of how information is presented to them (Slovic, 1986).

Due in part to technological advances, there are increasing numbers of risks that entail potential outcomes with low probabilities but highly significant negative consequences (Camerer & Kunreuther, 1989). For example, the chance of a nuclear reactor core meltdown is quite small, but if a meltdown actually were to occur, the effect would be catastrophic. There is evidence that has led many researchers to suggest that people are especially poor at interpreting such low probabilities (e.g., Camerer & Kunreuther, 1989; Halpern, Blackman, & Salzman, 1989; Kahneman & Tversky, 1979; Magat, Viscusi, & Huber, 1987). One possible reason for this difficulty is that people have little first-hand experience with probabilities of this magnitude as, by definition, low-probability events are rarely observed (Halpern *et al.,* 1989).

Given that people in general have difficulty interpreting such low probabilities, an especially important issue is just how these probabilities are encoded and represented. This issue is important in general, not just for low probabilities, and has been the subject of much study in a variety of contexts (e.g., Kahnemen & Tversky, 1979; Reyna & Brainerd, 1991). Nonetheless, this representational issue appears to be particularly difficult for low probabilities. For example, in prospect theory, Kahneman and Tversky (1979) hypothesize the existence of a π function, which translates probabilities into decision weights. These weights in turn directly affect the attractiveness of alternatives. As shown in Fig. 1, this π function contains a discontinuity at some low probability. Although it is unclear exactly where this discontinuity occurs, the essential idea is that low probabilities are overweighted until they reach some "sufficiently low" probability, at which point they are given no weight at all.

Similar ideas, although generally given in a more qualitative fashion, have been presented by researchers who focus in particular on low-probability risks. For instance, Magat *et al.* (1987) suggest that people are incapable of trading off low probabilities associated with potential outcomes against the consequences of those outcomes. Thus, they either inflate such probabilities to a level familiar to them or dismiss these probabilities by focusing solely on the magnitude of the outcomes. Similarly, Halpern *et al.* (1989) argue that people represent the absolute number of people affected by a low-probability risk as either a "large number" or a "small number" (p. 258), failing to make fine distinctions among such magnitudes.

The present study had two primary aims, one applied and one theoretical. Given that people do in fact have marked difficulty interpreting low probabilities, the type of framing effects discussed above may be especially pronounced for low-probability risks. If this is indeed the case, the

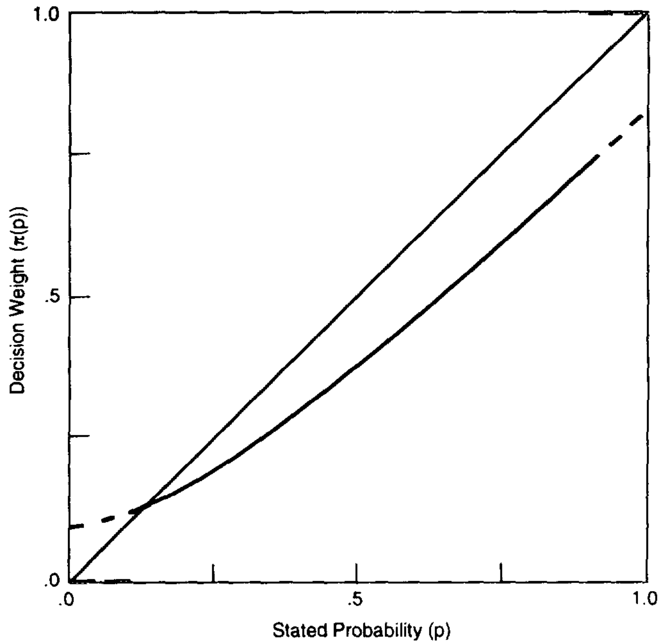

FIG. 1. A characteristic probability–decision weight relationship, according to prospect theory. Note that near probability .0, weights either drop to .0 or are significantly greater than their associated probabilities. Adapted from Fig. 4, Kahneman and Tversky (1979), with permission.

question naturally arises as to which frames will lead to the most risk-avoidant behavior. In addition, we expected that differences we uncovered in risk-avoidant behavior could serve as a window on how the risks are encoded and represented. Thus, determining what the representational differences are that mediate framing effects was the second goal of our experimentation. We begin by reviewing how risks are presented in the field of epidemiology, where this issue is of particular importance, and proceed to discuss our empirical examination of two of these methods.

RISK COMMUNICATION IN EPIDEMIOLOGY

Adequate communication about the risks attributable to various hazards is an issue of increasing concern to the general public. As a result, epidemiologists have been seeking better methods for measuring risk and communicating these risk assessments to the general public (e.g., Friedman, 1987; Streiner, Norman, & Blum, 1989). Despite this goal, there have been few systematic attempts to determine the effectiveness of various modes of presentation. For example, Popper and Murray (1989) remark that "even though cigarette warnings are the most frequently used health disclosure in the United States, the U.S. Surgeon General concedes that little is known of how (or even whether) the warnings have any communications effect" (p. 110). The focus of the present work is on determining the effectiveness of various formats for communicating comparative risks, such as between two different brands of cigarettes. We illustrate this issue below.

Consider the question of whether cigarette Brand X or Brand Y is a greater contributor to lung cancer. One of the most common measures in epidemiology is the *incidence rate*. The incidence rate is the number of persons developing a disease out of the total number of individuals at risk per unit of time (Friedman, 1987, p. 10). Thus, the annual incidence of cancer among Brand X smokers is the probability that, during a given year, a randomly selected Brand X user will contract lung cancer. Similarly, for Brand Y, the annual incidence rate is the probability that, during a given year, a randomly selected Brand Y user will develop the disease.

This comparison technique is indirect, however, in the sense that it requires one to examine a number for each brand and then compare the numbers. A more direct comparison is permitted by using the *relative risk* measure, which is defined as the ratio of the two incidence rates (Streiner *et al.*, 1989, p. 75). For instance, if the incidence rate of Brand X is .00125 and that of Brand Y is .0025, then the relative risk of Brand X to Brand Y is .5. In other words, the risk of Brand X is half that of Brand Y. This gives a second formally equivalent method of comparing the risks due to the two cigarette brands. As there are thus several mathematically equivalent ways of presenting comparative risk information, this raises the issue of whether the choice of format will affect risk-taking behavior, and if so, which format should be used in risk communications.

Halpern *et al.* (1989) examined a similar issue. Subjects read risk information about oral contraceptives framed in a variety of ways and rated how risky they thought oral contraceptive use was. The response procedure, adapted from methods employed by Slovic, Fischhoff, and Lichtenstein (1981), required subjects to rate the risk of oral contraceptive use in comparison to 11 other events. For example, subjects were asked to rate whether death due to a circulatory disorder for oral contraceptive users was more or less likely than death due to having an appendectomy. These ratings were collapsed across the different comparison events, and preplanned contrasts were performed to determine if there were differences in the ratings resulting from the different display formats.

The findings clearly demonstrated that the way the information was presented affected how risky the subjects judged contraceptive use to be. One of the display effects discovered by Halpern *et al.* has special importance for the present purposes. Subjects given relative risk information (e.g., that using oral contraceptives leads to a 415% increase in the risk of death from a circulatory disorder) rated oral contraceptive use as riskier than did subjects given frequency information (e.g., that 1 in 12,000 users dies). The authors speculated that the reason for the observed difference was that subjects in the frequency conditions knew the absolute death rate (for contraceptive users), which Halpern *et al.* termed "base rate" information, while those in the relative risk conditions were not given this information.

The Halpern *et al.* (1989) result is important in its own right and also bears directly on our goal of determining what format should be used in risk communications, as discussed above. However, it is an open question whether risk ratings, as articulated by Halpern *et al.'s* subjects, reflect how individuals would act in the face of potential hazards.

There are, in fact, a number of ways that such different ratings might not lead to differing decision behavior. First, not all changes in risk judgments will affect behavioral choices; instead, a change in judgment needs to surpass some "action threshold" before one's behavior will be altered (cf. Weinstein & Fineberg, 1980). Thus, differences in ratings on the order observed by Halpern *et al.*, although statistically significant, might be too small to be consequential when subjects trade off risks against benefits in actual decision making. Second, it is possible that these ratings would not even be taken into account in decision-making activities. Consider, for example, a person deciding whether or not to use oral contraceptives who employs a non-compensatory choice strategy such as elimination by aspects (Tversky, 1972). This person, regardless of the risk information display format, would be aware that the risk of death due to a circulatory disorder was greater when using oral contraceptives than when not using them. Thus, the decision made by this person would depend solely on how important the risk of death due to a circulatory disorder is for that person, not on how much greater the risk is when using oral contraceptives.

Moreover, even if using a compensatory strategy such as expected utility maximization, it is possible that subjects' decision making would be identical in both of Halpern *et al.'s* conditions. Being concerned with the judgment of risk when using oral contraceptives, Halpern *et al.* did not examine subjects' judgments of the risk of various outcomes when individuals were not using oral contraceptives. It is quite possible that, while subjects in the relative risk conditions believed the risk of cancer when using oral contraceptives to be higher than did subjects in the frequency conditions, they thought that the risk when not using oral contraceptives was higher as well. If this were the case, then the perceived *increase* in risk when using oral contraceptives could be identical for subjects in the relative risk and frequency conditions, which would lead to equivalent decision behavior in the two groups. It is, in fact, impossible to know if there would be a difference in decision behavior without knowing the risk judgments for people not using oral contraceptives as well as for those using oral contraceptives.

EMPIRICAL INVESTIGATIONS

The purpose of the present studies, then, was to determine the comparative effects on risk-taking behavior of risk information displayed in incidence rate and relative risk form. While it is important to establish the effects of all major risk communication formats,[1] we felt that since incidence rates and relative risk ratios are extremely common in epidemiology, they were ideal candidates for our initial investigation. For practical as well as ethical reasons, we were unable to study risk-taking behavior per se. However, examining professed behavior should allow us to identify the same factors that would affect actual behavior. There seems no reason to believe that, even if the effect magnitudes differ, there would be any differences in the way displays affect professed as opposed to actual behavior.

EXPERIMENT 1

As discussed previously, many researchers have suggested that sufficiently small probabilities may be treated as being essentially nil. We hypothesized, then, that subjects given particularly low incidence rates will tend to treat any subsequent risk reduction as being insubstantial, while subjects given a relative risk ratio will see the risk reduction as being meaningful. Thus, we predicted that subjects given relative risk information would demonstrate more risk-avoidant behavior than would subjects given two incidence rates whose ratio is equal to the focal relative risk.

Method

Subjects. Subjects were 108 University of Michigan students, participating in fulfillment of an introductory psychology course requirement. All subjects were female, as another task completed during the same session required that only female subjects participate.

Materials. Our materials were adapted from those used by Viscusi and Magat (1987), whose procedures were designed to evaluate consumers' trade-offs between a product's risks and cost (Magat *et al.*, 1987). As part of their study, Viscusi and Magat presented subjects with two hypothetical bleaches, each with an associated level of risk. Subjects were also

[1] Note that Halpern *et al.* employed a variation of the incidence rate in their study by converting the probability to *x* out of *y*. It is an open question whether that technique would produce the same or different results than simply giving the incidence rate.

told the current price for the bleach with the higher level of risk. The focal question was how much the subjects would be willing to pay to use the safer bleach. With this technique, then, it was possible to examine directly subjects' professed behavior as a result of varying the risk display format.

The present study used essentially the same procedure, and manipulated the presentation style of the risk information in accord with the different formats described above. As most college undergraduates are not particularly familiar with bleach, we changed the product of interest and included both tires and toothpaste as focal products. Specifically, we presented subjects with risk information concerning serious injuries resulting from tire blowouts and about contracting serious gum disease (Brown, Oliver, & Loe, 1990).[2]

As an illustrative example, consider the tires product. We told subjects there was a certain risk associated with what we called "Standard Tires," and that the manufacturer was considering marketing a new brand of tires. This brand would be identical in all respects to the former product, except that it would reduce the risk by a given amount. The subject was then given the price of the Standard brand of tires, and asked how much she would be willing to pay for the "Improved" product. Finally, the relevant information was summarized and presented to the subject in box form (see Fig. 2). The display for the toothpaste product contained similar information, except that instead of the risk of injury due to blowouts being .000006, the risk of serious gum disease was .006.

Procedure. All subjects were presented with either the tires or the toothpaste task. For each buying situation, subjects were shown information in one of two formats. Again using the tires product for illustrative purposes, the "incidence rate" condition gave the risk information in terms of two incidence rates (i.e., the probability of an individual suffering a serious injury when using Standard Tires and when using Improved Tires). For the "relative risk" condition, the standard product was described as "about average" and the improved product as having a risk "half that of" the standard product. Each subject was given one of these formats after first making a decision about the other product as part of another experiment.

Results and Discussion

Since the data were skewed to the right, we used a logarithmic transformation of the actual prices given by the subjects for all significance

[2] The authors thank Fritz Streff of the University of Michigan Transportation Research Institute for statistics on tire blowouts and Mahassen Farghaly of the Department of Community Dentistry at the University of Michigan for pertinent articles on periodontal disease.

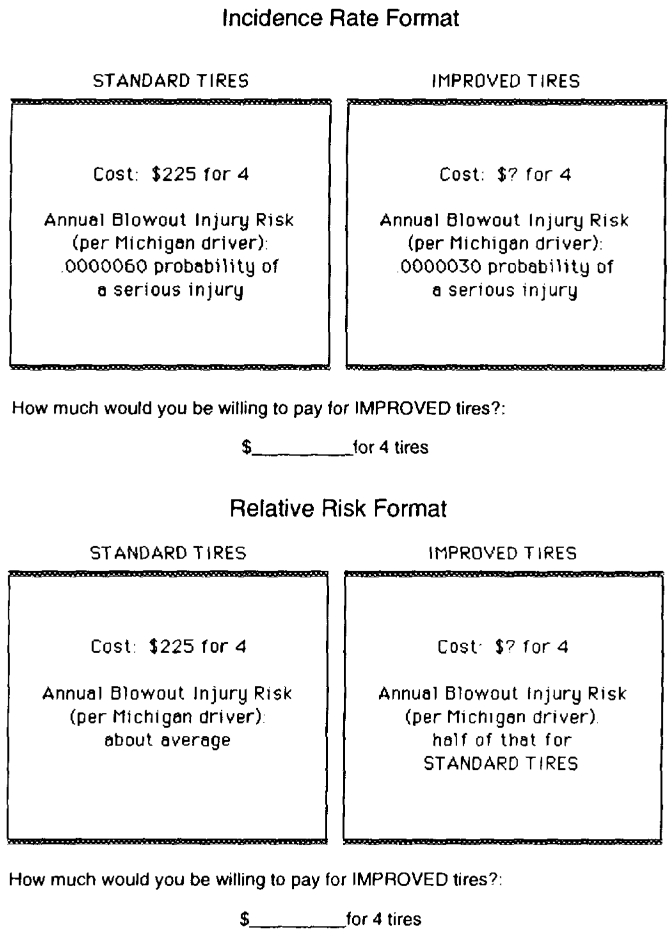

FIG. 2. Two illustrative examples of box summaries presented to subjects. They demonstrate the incidence rate and relative risk display formats for the tires product.

tests (see Lee, 1975, p. 291). Table 1 shows the results for the incidence rate vs relative risk comparisons. The effect of varying the display format was significant for tires but not for toothpaste. Subjects were willing to pay an additional $74 for the improved tires in the incidence rate condition, but were willing to pay an additional $129 in the relative risk condition, $t(52) = 2.05$, $p = .02$, one-tailed test. For toothpaste, however, subjects were willing to pay approximately the same amount in both conditions: $.83 and $.88 more in the incidence rate and relative risk conditions, respectively, $t(52) = .34$, *ns*.

Two explanations for the difference in results between the toothpaste

TABLE 1
MEAN PRICES SUBJECTS WERE WILLING TO PAY FOR THE SAFER PRODUCT IN EXPERIMENT 1

Product/activity	Condition: Incidence rate	Condition: Relative risk	One-tailed p values
Tires			
(Standard = $225)	$298.50	$353.54	.02
Toothpaste			
(Standard = $2.29)	$3.12	$3.17	ns

and tires conditions seem plausible. The first of these focuses on the incidence rates, and suggests that when presented with very small probabilities, as in the tires condition, subjects may "edit" them to essentially nil (see Halpern *et al.*, 1989; Kahneman & Tversky, 1979; Magat *et al.*, 1987). For the risk of gum disease, however, the likelihood was much higher (.006 for the Standard toothpaste), suggesting that subjects may have considered a subsequent risk reduction of .003 as a significant one. The basic idea behind this "editing" hypothesis is in keeping with fuzzy trace theory (Reyna & Brainerd, 1991). According to this theory, people extract the gist of information, and, when possible, reason on the basis of this gist. This is presumed to occur even if people have access to more concrete information (such as the actual risk levels in our experiment). Applying this framework to our present situation, our editing hypothesis suggests that subjects examine the reduction in risk and encode the gist of the risk reduction and make their decisions on the basis of this gist. More concretely, the editing hypothesis suggests that when presented with a risk reduction of .003, subjects will generally represent this reduction as "low, but significant." However, when the reduction is as small as .000003, subjects will represent it as "essentially nil" (see Fig. 3). In the relative risk condition, though, subjects will see the risk reduction as significant in all cases, thereby leading to the greater willingness to spend money for the tires product in that condition.

An alternative account for the inconsistency between the results focuses on the nature of the relative risk format. Unlike the incidence rate display, this format gives no information about the absolute magnitudes (base rates) of the various risks, and thereby conveys less information than do other formats (Halpern *et al.*, 1989). Thus, erroneous assumptions as to the base rates of one or both of the products could produce the results that we found. For example, consider the following hypothetical individual, Subject X, who responds equally strongly to relative risk information and to incidence rate information. Prior to the experiment, Subject X correctly assumed that the risk of periodontal disease was

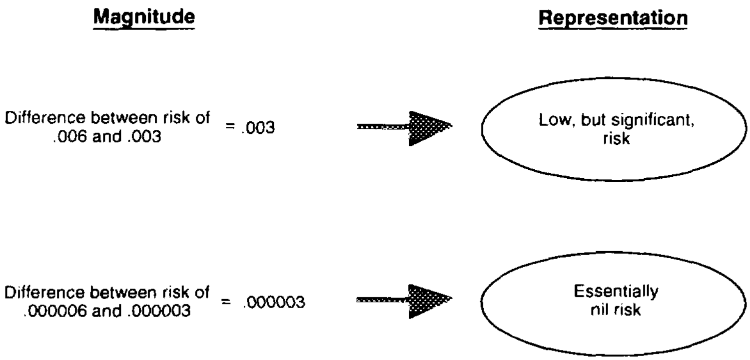

FIG. 3. A pictorial depiction of the proposed editing hypothesis.

about .006. She, like our average subject, would have her toothpaste purchasing behavior affected equivalently by the relative risk and incidence rates formats. But, Subject X does not have a good intuitive appreciation for the likelihood of serious injuries due to tire blowouts. In particular, she believes that the chances of being injured this way are much greater than they actually are. Then, when presented with incidence rates (and the actual chances of being injured), she will be willing to pay less money to reduce the risk than if she had only been given the information in relative risk form. We call this the "base rate overestimation" hypothesis, as subjects are proposed to overestimate the base rate for the tires product. However, it is worth noting that what is essential is that subjects do not have access to the base rates. Thus, it is possible that in some situations subjects might actually underestimate the base rate rather than overestimate it, thereby leading these subjects to demonstrate more risk-avoidant behavior when presented with incidence rates than with a relative risk ratio.

Experiment 2 was designed to test whether one, or both, of these explanations can help predict professed behavior in situations other than the ones discussed above. The approach we took was to construct different situations for which the hypotheses proposed above made concrete predictions and then examine the accuracy of those predictions.

EXPERIMENT 2

To evaluate the editing hypothesis, we constructed scenarios for products or activities different from those used in Experiment 1, but ones that had risks close to the levels associated with tires and toothpaste. In order to test the base rate overestimation hypothesis, we created scenarios that would induce people either to overestimate the base rates or to underestimate them. Specifically, we chose products or activities whose risks were either highly publicized by the media or whose risks were less publicized, relative to the actual risk magnitude. We thought that, through availability, subjects would assume that the risks associated with the highly publicized hazards would be greater than those associated with the less highly publicized ones (see Fischhoff, Slovic, & Lichtenstein, 1982). This gave a 2 × 2 factorial design, where the products/activities varied according to their actual risk level (low or high) and according to the amount of media exposure they received (low or high). The scenarios chosen to fulfill these conditions were concerned with burglaries of rental houses (high risk, high media exposure), chain saw accidents (high risk, low media exposure), airplane accidents (low risk, high media exposure), and amusement park ride accidents (low risk, low media exposure). (See Table 2.)

The editing hypothesis predicted that the relative risk format would induce greater risk-avoidant behavior than would the incidence rate format when the actual risk level was low, but that this difference should not occur when the risk level was high. According to the base rate overestimation hypothesis, however, relative risks should induce greater risk-avoidant behavior than incidence rates for products and activities whose risks are highly publicized by the media. On the other hand, for products and activities whose risks receive little media attention, the difference in risk-avoidant behavior should dissipate, or even reverse. Table 3 summarizes these predictions.

Given our use of such realistic scenarios, there were large differences in risk-taking behavior among our subjects. To control for some of these differences while maintaining our use of real-world scenarios, we also collected information on plausible covariates in this experiment. In particular, we noted each subject's gender, year in school, financial well-being, and familiarity with each product or activity.

Method

Subjects. Two hundred twenty-seven male and female University of Michigan students participated in the study in fulfillment of an introductory psychology course requirement.

TABLE 2
EXPERIMENTAL DESIGN AND ASSOCIATED ACTIVITY/PRODUCT HAZARDS IN EXPERIMENT 2

	Actual risk level	
Media attention	Low	High
Low	Amusement park ride injuries	Chain saw injuries
High	Airplane fatalities	Rental house burglaries

TABLE 3
EXPERIMENT 2 PREDICTIONS

Media attention	Actual risk level: Low	Actual risk level: High
	"Editing" hypothesis	
Low	Amusement parks RR > IR	Chain saws RR = IR
High	Airplanes RR > IR	Rental houses RR = IR
	"Base Rate Overestimation" hypothesis	
Low	Amusement parks RR ≤ IR	Chain saws RR ≤ IR
High	Airplanes RR > IR	Rental houses RR > IR

Note. IR = incidence rate display format; RR = relative risk display format.

Materials. We used the same general format for the questionnaires as was used in Experiment 1. As described previously, however, we generated four new scenarios. Specifically, the risks we used included: the risk of death per aircraft-hour (*Accident Facts,* 1990, p. 87), the risk of a serious injury from an amusement park ride ("The Fast Tracks," 1990, p. 7), the risk of an injury due to chain saw use ("Lawn Tractors," 1989, p. 368), and the risk of being burglarized in a relatively safe part of Ann Arbor ("Burglary-Prone Neighborhoods," 1989, p. 19).

We also administered a follow-up questionnaire to collect information on the covariates used in the study. In particular, we recorded the subject's gender, age, financial situation (on a 5-point scale ranging from "considerably below average" to "considerably above average"), and familiarity with each product (on a 3-point scale ranging from "not at all familiar" to "quite familiar").

Procedure. The procedure was similar to that used in Experiment 1, with each subject responding to either the incidence rate or relative risk format for one of the four products/activities. Subjects were given the follow-up questionnaire after completing the primary task.

Results and Discussion

As in Experiment 1, the data were skewed to the right, so we used a logarithmic transformation of the actual prices given by the subjects for all significance tests. Also, there were a number of cases where we combined the results of different scenarios, for reasons described below. To do this, we standardized the data by subtracting the sample mean for each product/activity and dividing by the relevant sample standard deviation.

This allowed us to aggregate the results, even though the means and variances differed from scenario to scenario.

Most of our tests were regression analyses, and followed the same format. We first entered any covariates that were significant at the .10 level, and then tested to see whether being in the incidence rate or relative risk condition had an effect on the prices subjects were willing to pay for the safer product. We followed this procedure because we were not interested in the effects of the covariates per se, but only in using them to reduce the large error variance associated with our dependent measure. Table 4 contains a list of the significant covariates.

Manipulation checks. To verify that our media manipulation was successful, we asked introductory psychology subjects to state how many times in the past year they had seen or heard a media report about each of our four scenarios. Subjects responded to the four questions as part of subject pool prescreening that is routinely conducted at the beginning of each school term. As predicted, students had been exposed to significantly more media reports about burglaries (Median = .630) than about chain saw accidents (Median = .300), $Z = 14.19$, $p < .0001$, via a sign test. Similarly, students recalled considerably more media reports about airplane fatalities (Median = 4.307) than about amusement park ride injuries (Median = .797), $Z = 23.51$, $p < .0001$, from a sign test.

Tests of the base rate overestimation hypothesis. Recall that the base rate overestimation hypothesis predicts that the relative risk format will lead to more risk-avoidant behavior than will the incidence rate format for

TABLE 4
SIGNIFICANT COVARIATES FOR DETERMINING RISK-AVOIDANT SPENDING RESPONSES IN EXPERIMENT 2

Product/activity	Significant covariates[a]
Low media	· None
High media	· Female > Male
	· Younger student > Older student
Low risk	· Female > Male
	· Younger student > Older student
High risk	· Higher financial well-being > Lower financial well-being
	· Less familiar > More familiar
Amusement parks	· Female > Male
Airplanes	· Female > Male
	· More familiar > Less familiar
Chain saws	· None
Rental houses	· Female > Male
	· Less familiar > More familiar

[a] Subjects in the category before the > were willing to pay more, on average, than were the subjects in the category after the > ($p < .10$).

those scenarios whose risks are highly publicized, but that there will be no difference (or possibly even more risk-avoidant behavior in the incidence rate condition) for those scenarios with risks that are not as highly publicized. To test these predictions, we combined amusement park rides and chain saws to form a low-media group and airplane flights and rental houses into a high-media group, using the standardization technique described above. We then performed regression runs for each of the two groups to determine if there was an effect of the display format. Neither prediction of the base rate overestimation hypothesis was verified. In particular, there was no effect of display format in the high-media group, $t(72) = .06$, *ns*. For the low-media group, subjects were actually willing to pay more for the safer product in the relative risk condition than in the incidence rate condition, $t(70) = 2.12$, $p = .04$, two-tailed, which is the reverse of what the base rate overestimation hypothesis predicts. As will become apparent shortly, these results are readily explained by the editing hypothesis.

Tests of the editing hypothesis. The editing hypothesis predicts that subjects will demonstrate more risk-avoidant behavior when presented with the relative risk display as opposed to the incidence rate format only when the absolute risk magnitudes are sufficiently low. To evaluate this hypothesis, we combined airplane flights and amusement park rides to form a low-risk group and rental houses and chain saws into a high-risk group. As predicted, for the low-risk group, subjects were willing to pay more for the safer product in the relative risk condition than in the incidence rate condition, $t(66) = 2.36$, $p = .01$, one-tailed. For the high-risk group, the difference between the formats was clearly non-significant, $t(74) = .21$, *ns*.

To further highlight the difference between the low- and high-risk groups, we performed an analysis of covariance with risk level (low vs high) and display format (incidence rate vs relative risk) as independent variables and year, gender, and financial status (all significant at the .10 level) as covariates. The interaction between risk level and display format was significant, $F(1,141) = 3.83$, $p = .05$, implying that the effect of the display format does depend on the risk level.

Finally, suppose the editing hypothesis holds, and subjects treat the probabilities as essentially nil when presented with incidence rates for the low-risk scenarios. Then, subjects should be unwilling to buy the improved product if it is at all more expensive than the standard product and thus be unwilling to pay *any* additional amount for the safer product. Although it was rare for subjects in any condition to be unwilling to pay something extra for the safer product, the results do support the prediction that subjects would be less willing to pay anything extra when presented with the incidence rate display than with the relative risk format.

In particular, for the two low-risk products, 6 out of 36 subjects in the incidence rate condition were unwilling to pay any additional amount for the safer product, while only 1 out of 34 subjects in the relative risk condition was unwilling to pay anything extra. Using Fisher's exact test, this difference was marginally significant ($p = .06$). For the high-risk products, 1 out of 40 subjects in the incidence rate condition was unwilling to pay anything to decrease the risk, and none of the 39 subjects in the relative risk condition was unwilling to pay anything extra. This difference is nonsignificant ($p = .51$ by Fisher's exact test). We next turn to an analysis of the individual scenarios to determine how consistently the predictions of the editing hypothesis were verified.

Individual scenarios. The mean prices that subjects were willing to pay for the safer products are shown in Table 5. For amusement parks, subjects in the relative risk condition were willing to pay $4.09 more for the safer rides than were those subjects in the incidence rate condition, $t(30) = 2.65$, $p = .02$, two-tailed. When presented with relative risk information on airplanes, subjects were willing to pay $8.46 more for the improved flights than were those subjects in the incidence rate condition, $t(33) = 1.33$, $p = .10$, one-tailed. However, subjects were only willing to pay $6.75 more for safer chain saws in the relative risk condition than in the incidence rate condition, $t(37) = .61$, *ns*. And finally, the price subjects were willing to pay for a safer rental house was actually $10.47 less in the relative risk condition than in the incidence rate condition, $t(35) = .04$, *ns*.

By referring to Table 3, we can see that the data in all four cells support the predictions made by the editing hypothesis. For both amusement park rides and airplane flights, subjects were willing to pay more in the relative

TABLE 5
MEAN PRICES SUBJECTS WERE WILLING TO PAY FOR THE SAFER PRODUCTS IN EXPERIMENT 2

	Condition		
Product/activity	Incidence rate	Relative risk	*p* values
Amusement parks			
(Standard = $20)	$25.08	$29.17	.02*
Airplanes			
(Standard = $195)	$246.17	$254.63	.10†
Chain saws			
(Standard = $125)	$174.00	$180.75	ns†
Rental houses			
(Standard = $325)	$381.00	$370.53	ns†

* Two-tailed test.
† One-tailed test.

risk condition than in the incidence rate condition, although this effect was only marginal for airplane flights. Futhermore, for chain saws and rental houses, there was no significant difference between the incidence rate and relative risk conditions in the amounts subjects were willing to pay for the improved products. Examination of the base rate overestimation predictions, however, shows that, although the airplane flight and chain saw data agree with the predictions, the results for amusement park rides and rental houses run counter to the predictions. Thus, an analysis of the individual products or activities further supports the editing hypothesis over the base rate overestimation hypothesis.

Additional data. In general, the predictions of the editing hypothesis were confirmed. The only potential inconsistency was that the effect associated with airplane flights was only marginally significant, thus making its interpretation somewhat ambiguous. We therefore decided to increase our sample size for the airplane scenario to determine if that effect was real or due to chance.

Combining our new airplane flight data with the old produced a clear effect due to the display condition. Subjects in the relative risk condition were willing to pay $266 to reduce the risk, while subjects in the incidence rate condition were only willing to pay $245, $t(94) = 2.05$, $p = .02$, one-tailed. Similarly, combining the two data sets allowed us to reexamine whether subjects in the incidence rate condition were less likely than subjects in the relative risk condition to pay any additional amount for the safer product. Ten out of 66 subjects were unwilling to pay any additional amount for the safer product in the incidence rate condition, while only 2 out of 63 subjects were unwilling to pay more in the relative risk condition ($p = .02$ by Fisher's exact test).

GENERAL DISCUSSION

As predicted by the editing hypothesis, it appears that extremely low incidence rates are represented as essentially nil by many subjects. Therefore, for products or activities with exceptionally low risks, providing risk information in relative risk form will lead to more risk-avoidant behavior than will providing the information in incidence rate form. Assuming the robustness of these results, two issues seem to be of particular importance: (1) how large (in a practical sense) are these effects? and (2) how does one interpret the editing hypothesis in light of the large variability in the data? We will discuss each of these questions in turn.

Effect Magnitude

At first glance, it appears that the magnitude of our effects is quite large. Considering both of the experiments, we had subjects express how much they would be willing to pay to reduce the risk for three products or activities which contained low absolute levels of risk (all less than .00001). The mean dollar amounts subjects were willing to pay to reduce the risk for these three scenarios are shown in Table 6. Note that subjects were willing to pay over $55, $21, and $4 *more* to reduce the risk of tire blowouts, airplane fatalities, and amusement park ride injuries, respectively, in the relative risk as compared to the incidence rate condition.

There are at least two reasons, however, why these dollar amounts are likely to be overestimates. The first is that we are considering professed rather than actual consumer behavior. It seems quite possible that subjects would not be willing to spend as much in practice as they say they would in a hypothetical task (see e.g., Wicker, 1969). To the extent that the actual dollar amounts are overestimates, the differences become exaggerated as well. A related problem is that there may be subtle demand characteristics present in the experiment. Asking what subjects would be willing to pay for the safer product suggests they should be willing to pay *something* extra, and to the extent that they do not want to appear foolish (and risk taking) they may feel as if they ought to pay a lot extra. Note that both of these difficulties, the professed rather than actual behavior and the possible demand characteristics, should affect the incidence rate and relative risk conditions similarly. Thus, they should not affect the reliability of our results. Nonetheless, they may well affect the magnitude of our effects, and the differences in dollar amounts can best be considered as upper bounds.

Given these difficulties, perhaps a better approach for determining the magnitude of the effect is to compute the percentage extra that subjects would be willing to pay when presented with risk information by means of a relative risk display rather than by an incidence rate format. As shown in Table 6, these percentage increases are 75, 80, and 43% for automobile

TABLE 6
MEAN ADDITIONAL AMOUNTS SUBJECTS WERE WILLING TO PAY FOR THE SAFER PRODUCT OR ACTIVITY IN THE LOW-RISK SCENARIOS

	Condition				
Product/ activity	Incidence rate	Relative risk	Difference	Percentage difference	ω^2
Automobile tires (Standard = $225)	$73.50	$128.54	$55.04	75%	.056
Amusement parks (Standard = $20)	$5.08	$9.17	$4.09	80%	.146
Airplanes[a] (Standard = $195)	$49.54	$70.79	$21.25	43%	.032

[a] This includes the additional data gathered for the airplanes scenario.

tires, amusement park rides, and airplane flights, respectively. Note that the potential problems discussed above will not affect these percentages, under the reasonable assumption that they will influence the two conditions equivalently. Thus, while we do not have a good estimate of how much (in dollar terms) the relative risk display will increase subjects' willingness to spend beyond that of the incidence rate format, the percentage increase appears to be substantial.

Interpretation of the Editing Hypothesis

We now turn to the question of how to interpret the editing hypothesis given the large individual differences in the data. First, it needs to be emphasized that even for the scenarios with extremely low absolute risk levels, not all subjects presented with the incidence rate format behaved as if the risk were nil. In fact, only 12 out of 183 subjects were unwilling to pay anything extra for the safer product or activity in our three low-risk scenarios. And while many subjects were willing to pay only a small amount more, there were also many who were willing to pay a great deal extra. Part of the explanation for this inconsistency undoubtedly lies with our use of professed rather than actual behavior and the potential demand characteristics, as discussed previously. It is possible, for example, that a subject thought the risk was essentially nil, but felt as if she were supposed to pay some amount extra for the safer airplane ride and thus offered $75 more for the ticket.

Nonetheless, given the large number of subjects who were willing to pay a reasonable amount extra for the safer product in the incidence rate condition, it seems questionable that all subjects in that condition were editing the risk to "essentially nil." One possibility is that some subjects edited the risk to essentially nil, and others represented the risk at the same level as those given the relative risk display, along the lines of Magat *et al.'s* (1987) suggestion that people either inflate low probabilities to a more familiar level or else dismiss them entirely. If this is the case, then the right halves of the distributions of responses for the relative risk and incidence rate conditions should be similar, as subjects given both display formats should be representing the risk at about the same level.

To examine this possibility, we aggregated across the three low-risk scenarios by using the standardization technique employed in Experiment 2 and graphed the distributions of responses for both the incidence rate and the relative risk display formats. As evident in Fig. 4, the incidence rate distribution is shifted to the left of the relative risk distribution across the entire range of responses. Thus, it is not the case that some subjects in the incidence rate condition were inflating the risk to the same level as those presented with the relative risk display, as in that case the right halves of the distributions would be similar. Instead, it appears that in

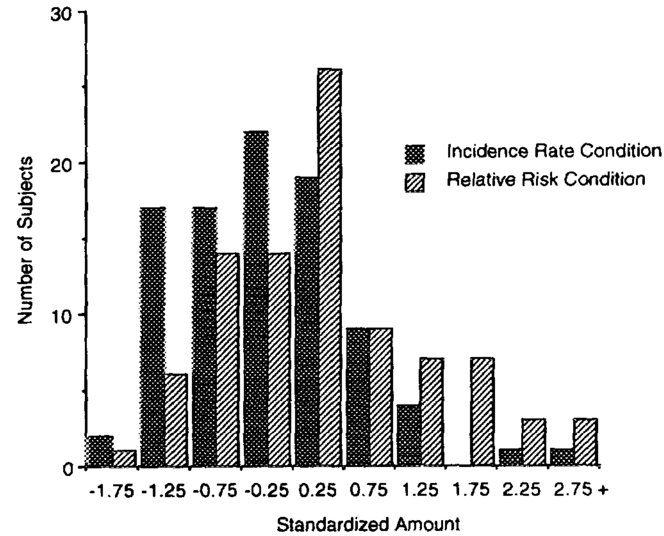

FIG. 4. Histograms of the standardized amounts subjects were willing to pay in the incidence rate and relative risk conditions aggregated across tire blowouts, airplane fatalities, and amusement park ride injuries.

general subjects presented with the incidence rate display represented the risk at a level less than that of subjects in the relative risk condition. The fact that some subjects in the incidence rate condition were willing to pay a reasonable amount extra (although less than the largest amounts paid by subjects in the relative risk condition) could be explained by the professed vs. actual behavior distinction and the demand characteristics discussed earlier. Alternatively, the typical subject might not have edited the risk to essentially nil, but instead simply represented it as "a very small number." Further research is needed to determine the exact form of the representation.

One final comment is worth making about the representations of the risk in the two display formats and how this relates to our applied goal of determining which risk measure should be employed. We have argued that presenting extreme low-probability risks in incidence rate form leads to the risks' being represented as "essentially nil" or at least as some very small number. This does not imply, however, that relative risk information is perfectly understood, or that the use to which this information is put is in any sense optimal. Instead, what we have demonstrated is that displaying small risks in a relative risk format will lead to more risk-avoidant behavior than will displaying the same information in incidence rate form. There is no necessary reason to believe that employing formats which increase preventive behavior also implies greater understanding on the part of the consumer as to the magnitude of the risk. Many risk specialists write as if the ultimate goal of their research is to provide methods of communicating risk information so that the information will reduce risk taking as much as possible. Instead, we believe, the ultimate goal should be to communicate risk information so that the consumer has as accurate an understanding of the degree of the risk as possible, so that he or she can utilize it in trading off risks against benefits when making a decision (see, e.g., Crouch & Wilson, 1982; Fischhoff, Lichtenstein, Slovic, Derby, & Keeney, 1981). From a practical standpoint, it is difficult, if not impossible, to measure whether the consumer accurately understands the magnitude of the risks (though the procedure used by Halpern *et al.*, 1983, and by Slovic *et al.*, 1981, may produce a partial answer to this question), and in many cases (e.g., in providing information about AIDS) applying formats that encourage risk reduction as much as possible seems an acceptable substitute. Nonetheless, it should be recognized that the implications of the present research apply to how to increase preventive behavior, and should not be employed blindly without consideration of whether this is a legitimate goal in the given situation.

Future Directions

In addition to the experiments reported here, we have actually performed a number of other studies that are relevant to our theoretical goal of understanding how risk information is represented and to our applied goal of determining which format will lead to more risk-avoidant behavior. These studies were generally pilot experiments and do not merit full discussion. Nonetheless, they have provided us with some guidance as to the route future research might take, and we offer information about them here in order to assist other researchers in this area.

Most of the discussion in this manuscript has focused on the manner in which incidence rate information is represented, with little attention devoted to the relative risk format. Previous to Experiment 2, however, we thought that lack of knowledge of the absolute risk magnitudes in the relative risk condition was at least partially responsible for the difference between the responses to the incidence rate and relative risk formats. Thus, we included a third condition in Experiment 2 where we presented *both* the incidence rate and relative risk information (e.g., the risk is .00000017 and one-half that of Standard Airplanes). We hypothesized that presenting the absolute risk magnitudes in addition to the relative risk ratio might eliminate the difference between the relative risk and incidence rate conditions. Although there was a small trend in that direction, in general this prediction was unsupported, as for none of the products or activities was there a significant difference between the relative risk and "composite" formats. This finding strengthens the conclusion that it is not faulty estimation of the risk magnitudes that leads to the greater risk-avoidant behavior in the relative risk condition. It does not, however, explain how relative risk information is being represented. A major emphasis of future research should be on just how people think about this relative information when making decisions.

In terms of its applied aim, this research has examined two of the most common risk measures used in risk communication. Nonetheless, there are many other displays which are frequently used and need to be studied systematically. Perhaps the most common of these entails describing the incidence rate information in terms of frequencies, i.e., as x out of y instead of as a probability (see Halpern *et al.*, 1989). Indeed, Streiner *et al.* (1989, p. 67) comment that incidence is frequently stated as cases per 1,000,000 to make the information more readable. In pilot work, we presented subjects with the tire blowout scenario and found that subjects given the incidence rate information as 30 out of every 5,000,000 Michigan drivers were willing to spend $28 beyond what the subjects given the incidence rate in probability form were willing to spend for the safer tires. Although these results are only tentative, they do suggest that presenting the incidence rate in a frequency format is worthy of future study.

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