The Journal of Social Psychology, 134(4), 511–527

Actions, Attitudes, and Perceptions Regarding Six Technologies

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ABSTRACT. In a survey conducted in 1982–1983 on risk perception, judgment of the acceptability of existing safety regulations, and activism among the general public and opinion leaders for six technologies (Gould et al., 1988), little or no correlation was found between perception, attitude, and activism. In a secondary analysis of these data, using the log-linear approach, we found that (a) judgment of the acceptability of existing safety regulations plays a pivotal role both in determining the perception of risk/benefit attributed to a technology and in influencing the status and type of activism, and (b) the relationships observed between variables held true both for the general public and for opinion leaders. The implications of these findings are that (a) risk communication should entail not only communication about risks but also communication about the resources that are available to protect oneself against these risks and (b) the current view that experts form their opinions and base their actions on different, more rational and quantitative premises than the general public may need to be revised.

IN DEMOCRACIES SUCH AS THE UNITED STATES, technology risk-management institutions, including those that regulate safety, are supposed to represent public sentiment about a technology's benefit/risk trade offs. Members of the public, on the other hand, are supposed to make an informed judgment on the adequacy of risk management along with the existing safety regulations and, when necessary, to act in a way that expresses their judgment. Furthermore, a presupposed ideal condition is that the public has the right to information and that the technology risk-management experts are effectively engaged in risk communication.

In a 1982–1983 survey (Gould et al., 1988) on the views of both the general public and opinion leaders ("intervenors" who had served as witnesses in public hearings) on six technologies—nuclear power, nuclear weapons, industrial chemicals, auto travel, air travel, and handguns— two surprising results emerged. First, in a comparison of perceptions of relative risks and benefits with the degree of acceptability of existing safety regulations for each technology investigated, an expected association between the assessment of a technology as having higher benefits than risks and a high level of acceptability of existing regulations was not found. Second, the degree of activism, either support for a technology because of its benefits (called "pro-benefit" in that study) or advocacy of decreased deployment of the technology (called "pro-safety"), showed little or no correlation with either risk/benefit perception or with safety acceptability.

The authors concluded that risk-management issues concerning some of the investigated technologies did not appear to be salient enough for the public to form consistent sentiments and to take consequent actions. In an earlier study (Gardner et al., 1982) focusing on nuclear power and surveying a purposive sample of scientists and college students, however, no such anomalies were found. Their conclusion implies that current modes of risk communication in American society are inappropriate or inadequate; the results also suggest that risk-management authorities, technological experts, and concerned opinion leaders all have a responsibility to communicate information so that the public may form more consistent opinions.

Original Data Analysis

Because important societal implications arise from these survey findings, ascertaining the empirical validity of the original data analysis was warranted. We reexamined the data, using an alternative analytical and methodological approach, and found that the anomalies Gould and associates found did not exist. Indeed, significant associations could be found between perceptions of risks and benefits, attitudes toward the acceptability of existing safety standards, and degree and type of activism. In this article, we present these findings in more detail, demonstrate the particular advantages and strengths of the method used, and discuss fruitful directions for future research. First, we discuss some of the problems connected with the methodological approach of Gould and his associates.

We gratefully acknowledge Jan A. J. Stolwijk of Yale University, who made the database available, and Douglas Sloane of The Catholic University of America, who read an earlier version of this article.

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Correlation/Regression Approach

Gould and his associates used a nonparametric version of correlation/regression analysis, justifying their choice with the following arguments. First, the data were mostly measured in nonequal interval scales and hence were treated with nonparametric statistics. Second, the correlation/regression approach enabled the authors to estimate net effects of independent variables, using a multivariate analysis, as well as zero-order effects, using a bivariate analysis.

One problem with this approach, however, is that correlation/regression analyses—whether parametric or nonparametric—are marginally dependent. The associations they estimate are greatly affected by the underlying distributions (or marginals) of the variables involved in those associations. When the variables selected for analysis have little variance (as in the case of a skewed underlying distribution), one can expect that covariations between the variables will be small, and, hence, few, if any, correlations will be detected.

The two key dependent variables of the 1980s study—namely, degree of acceptability of existing safety regulations, on the one hand, and degree of activism with the intent to change these regulations, on the other—are a case in point. The levels of activism of subjects associated with several of the technologies were generally low, especially concerning the sample of the general public. Consequently, the measures of activism showed little variance. Similarly, the attitudes toward safety regulations showed little variability among the general public, most of whom desired standards more rigorous than those existing. Given these small-variance measures as the dependent variables, one could expect that the results of a multivariate analysis involving a large number of independent variables would yield few significant associations.

The Augmented Sample

To augment the degree of variation, at least for the activism variable, Gould and his associates chose to combine their two separately collected samples of opinion leaders and the general public. They admitted that this was not a standard practice, and therefore the validity of their findings might be open to question. The study did, indeed, show that opinion leaders and the public at large differed on a wide variety of important dimensions: their judgments on the acceptability of safety standards, their perceptions of the risks and benefits relating to the technologies investigated, and their degree of activism.

An alternative methodological approach based on log-linear statistics can adjust and control for these differences and estimate net effects of the major independent variables. The database reanalyzed in this study was obtained from one of the authors of the original study (Gould et al., 1988).

Categorical Measurements and Log-Linear Approach

In the 1980s study (Gould et al., 1988), activism was measured by any of the following forms of participation: wrote a letter; signed or circulated a petition; voted, attended, or spoke at a public hearing; boycotted a company; joined or contributed to an organization; attended a demonstration; participated in a lawsuit; and other. In our re-analysis, we adopted the qualitative measurement scale used by Gould and his associates and distinguished three different statuses of activism: (a) nonactivism, (b) activism for further development of a technology without added safety regulations ("pro-benefit" activism), and (c) activism intended to decrease use or improve safety of a technology ("pro-safety" activism).

The measurement scale for "acceptability of existing safety regulations" was regarded in our analysis as categorical. Respondents were classified according to their answers to two questions for each technology: (a) "How strict do you think the standards are NOW?"; (b) "How strict do you think the standards should be?" The answer to each of these questions was classified on a scale ranging from *not very strict* (1) to *extremely strict* (7). The respondents were then classified as either "accepting" or "not accepting" of the existing safety standards; this classification was based on the calculated arithmetic difference between the answers on these two scales. If, for instance, the answer to the "should" question was not greater than the answer to the "now" question, the respondents were classified in the acceptable category. Otherwise, they were classified into the not acceptable category.

To measure the perception of risks and benefits for each technology, we used a composite version of the scores obtained by Gould and his associates. They had demonstrated that the respondents' perceptions of risks and benefits for a specific technology depended both on quantitative assessments (e.g., number of deaths) and on qualitative assessments (e.g., catastrophic potential). We therefore simply compared the average of scores for all measured dimensions of risks and benefits. If a respondent's average score for a technology's benefits was not higher than that for risks, she or he was coded as "risk." If, on the other hand, she or he had a lower risk than benefit score average, then the respondent was coded as "benefit."

For these three categorical variables—(a) activism (three categories), (b) acceptability of safety standards (two categories), and (c) perception of risks/ benefits (two categories)—and maintaining the distinction between the general public and the opinion leaders (two categories), we cross-classified the combined samples of respondents from two states (New Jersey and Arizona) in a $3 \times 2 \times 2 \times 2$ contingency frequency table for each of the six technologies. These 6 four-way contingency frequency tables served as the empirical bases on which 6 two-way associations, 4 three-way associations, and 1 four-way association were investigated for their statistical significance (using the stepwise "Hierarchical Log-Linear" program of SPSS).

To re-analyze the data, we opted for a log-linear approach for the following reasons. First, the marginal distributions of all of the selected variables are considered as given, so that associations between variables can be investigated independently of the underlying (skewed) distribution of any variables.

Second, no presupposed uniform model is needed for investigating the variable effects across six different technologies. Each of the two-way and multiway associations is tested for statistical significance in a hierarchical fashion, and a parsimonious model is identified to describe those associations. For example, if the public and opinion-leader respondents are similar in their perceptions of air travel's benefits and risks, the effect of those perceptions on activism can then be estimated after collapsing the public and opinion leader samples together. For other technologies, however, the situation may be different, and the perceptual difference between these two groups must be maintained in the model. To identify the preferred model—a reduced model retaining only the statistically significant associations for each of the six technologies—was therefore the first task in the following data analysis.

Third, a partial association between two variables may be expressed in terms of a higher order association when a third-variable distribution is extremely skewed. For instance, if activism is very low for a given technology, the association between perception of the technology's risks and benefits and attitude toward the existing safety standards can be estimated only with the nonactivist sample.

Results

The Fitted Models

The statistical significance of associations in a multiway contingency table is tested with the likelihood-ratio statistic (L^2) which measures the discrepancies between observed frequencies and expected frequencies by considering their ratios, rather than their arithmetic differences as in the conventional Pearson's chi-squares. The preferred log-linear model is identified by retaining all the significant associations, and its expected frequencies are again tested with likelihood-ratio statistics against the observed frequencies for statistically significant discrepancies.

The models chosen as preferred for the six technologies concerned are shown in Table 1. For each, the four-way contingency table was investigated for the statistical significance of 6 two-way associations, 4 three-way associations, and 1 four-way association. Except for the associations for handguns, the associations in the four-way tables for all technologies were simplifiable to a less-than-saturated model. As indicated by the L^2 statistics with the corresponding degrees of freedom for the fitted models, the reduced models for all five technologies (except handguns) would reproduce the four-way contingency tables with ex-

TABLE 1
The Fitted Log-Linear Models for the Six Technologies

Technology	Margins fitted	*df*	L^2	*p*
Air travel	SR, PR, SA, RA	12	10.91	.54
Auto travel	SR, PR, SA, RA	12	9.88	.63
Nuclear weapon	SR, PR, SA, RA, PA	10	17.12	.07
Chemicals	SR, PR, SA, RA, PA, SP, PRA			
Nuclear power	SR, PR, SA, RA, PA, SP, SPA	7	6.72	.46
Handguns	SPRA	0	0.00	1.00

Note. S = sample (public vs. intervenors); P = perception (more benefits vs. more risks); R = regulation (acceptable vs. not acceptable); and A = activist status (pro-safety, pro-benefit, and no action). For handguns, SPRA, all two-way, three-way, and four-way associations were statistically significant.

pected frequencies that were not significantly different from the observed frequencies.

Air travel and auto travel fit well with four of the six possible two-way associations. The perceptions of risks/benefits were not significantly different for the samples of the opinion leaders ("intervenors"; the term is consistent with usage in the original study by Gould and his associates) and by the general public; and the perceptions of risks/benefits were not significantly associated with status of activism. Rather, it was the perception of risks/ benefits that affected attitude of acceptability of the technology safety standards; and the latter, acceptability, in turn affected the activism status. Regarding the rest of the technologies, the perceptions of risks/benefits as well as attitudes regarding acceptability of safety standards were directly related to the status of activism. The commonality underlying the fitted models for all six technologies, however, was the significance of two-way associations of Sample × Activism, Sample × Regulations, Perception × Regulations, and Regulations × Activism (following the symbolism in Table 1: S = sample of intervenors and the public, P = perception of risks/benefits, R = attitudes toward safety regulations, and A = activism status). For all six technologies, therefore, the intervenors and public were significantly different in activism status and in attitudes regarding the acceptability of safety standards. And, although perceptions of risks/benefits may or may not directly affect the activism status, judgment of the acceptability of regulations always does.

Given that one's attitude regarding acceptability of safety standards was consistently associated directly with activism status, and acceptability was consistently affected directly by risks/benefits perceptions for all of the technologies, the effect of perception on activism could have been direct or indirect depending on particular technologies. A path model (Figure 1), in which the solid-line arrow represents a consistent direct effect and a broken-line arrow indicates an effect contingent on types of technologies, is helpful for summarizing the interrelation-

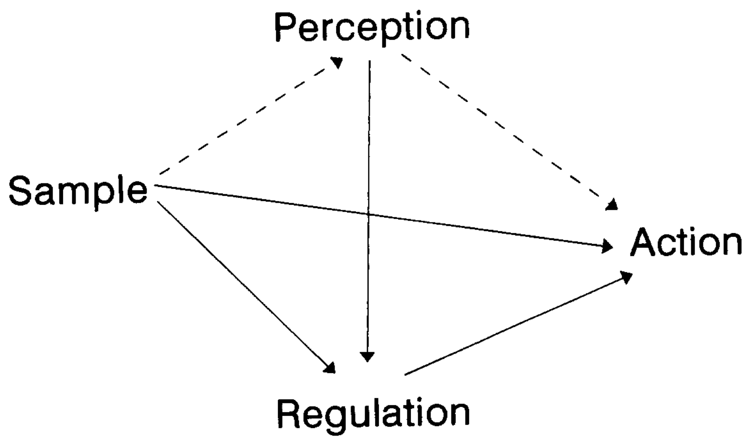

FIGURE 1. A general path model for the interrelationships between perception of risk, judgment on regulation, and action toward six technologies.
→= direct and consistent effect. --→= not always direct and consistent effect.

ships of the four variables: sample (intervenors vs. the public), perception (greater risks vs. benefits), regulation (not acceptable vs. acceptable), and activism (pro-safety, pro-benefits, and nonactivist). In short, the intervenors were consistently different from the public in attitudes toward regulation and in likelihood of assuming an activist status, especially the pro-benefits stance. Attitudes toward regulations consistently and coherently influenced the activist status. However, the intervenors' perceptions of risks/benefits were not always different from those of the public, depending on the specific technologies; and the risks/benefits perception, though consistently related to attitudes toward regulations, did not always directly induce actions in one way or another.

The preceding discussion provides an overview of the fitted models for the six technologies that we investigated. We now turn to the detailed patterns of variable associations concerning each of the technologies, beginning with the simplest fitted models (air travel and auto travel) and moving to the most complex (handguns). With the level of activism as the dependent variable, the trichotomous activist status was expressed in terms of two odds: the odds of pro-safety activism to nonaction, and the odds of pro-benefit activism to nonaction. Whenever there were significant two-way associations, we used these two odds to compute odds ratios across categories of the second variable. Whenever there was a significant three-way association, the odds ratios computed in association with the second variable were displayed for different categories of the third variable. When the four-way association for a four-way table was significant, we tabulated the odds ratios of two-way associations for each of the categories of the third and fourth variables, considered jointly.

Air travel. The expected frequencies (see Table 2) were from the preferred model. They did not differ significantly, in a statistical sense, from the observed frequencies. Estimating patterns of variable associations on the basis of expected frequencies was done to eliminate the statistical "noise" from the pattern of those associations. The model fitted for air travel specified that sample was significantly associated with regulation; intervenors were less likely than the general public to find existing regulations unacceptable. In addition, perception was significantly associated with regulation; those perceiving more risk would logically find existing regulations less acceptable. Thus, there were extremely few in either the intervenors or the public sample who reported engaging in pro-safety (or further increasing safety design or features) activism. Pro-benefit activism, on the other hand, was not particularly high for air travel, relative to other technologies. However, the nonzero cells under pro-benefit activism enabled us to describe the patterns: Intervenors were about twice as likely as the public to engage in pro-benefit activism (an odds ratio, .101/.052 = 1.94). Moreover, those who judged the existing safety standards to be unacceptable were more likely to be activists by a factor of 1.5 (.058/.038 = 1.53). Because activism, in this case, is pro-benefit, activists in air-travel-technology issues appeared to take the stand, at the same time, that imposing additional air-travel-technology safety requirements would be too expensive. We could not determine whether this was a statistical aberrant outcome resulting from an extremely small number of activists, in this case, or if it represented the actual logic of these activists.

Auto travel. The level of activism regarding auto travel appeared to be substantially higher than the level for air travel (compare the odds for auto travel with those for air travel, see Table 2). Relative to nonaction, the odds of pro-safety activism were .19 for the public and .35 for the intervenors, whereas the odds of pro-benefit activism were .06 for the public and .08 for the intervenors. Taking ratios of these odds, we found that the intervenors were almost twice (.347/.188 = 1.85) as likely as the public to involve themselves in pro-safety activism, and roughly 1.5 times (.083/.057 = 1.46) as likely to be involved in pro-benefit activism. For both the intervenors and the public, those who assessed the existing regulations as unacceptable were twice (.216/.103 = 2.10) as likely as those who found the regulations acceptable to take action for safety. The reverse was also true: Those who found the safety standards inadequate were less likely to be active on behalf of the benefits of the technology by a factor of .25 (.033/.131 = .25).

Nuclear weapons. Levels of activism concerning nuclear weapons were substantial even among the general public. The levels were different for intervenors and

TABLE 2
Expected Frequencies

Sample	Regulation acceptable	Activist status			Odds	
		Pro-S	Pro-B	No act	Pro-S/No act	Pro-B/No act
Air travel (Model: SR, PR, SA, RA)						
Public						
Benefit	No	–	26.9	464.0	–	.058
Benefit	Yes	2.6	7.9	210.1	.012	.038
Risk	No	–	8.1	140.0	–	.058
Risk	Yes	0.4	1.1	29.8	.013	.038
Total		3.0	44.0	843.9	.004	.052
Intervenors						
Benefit	No	–	13.1	109.1	–	.120
Benefit	Yes	1.8	7.9	100.7	.018	.078
Risk	No	–	3.9	32.9	–	.120
Risk	Yes	0.2	1.1	14.3	.014	.077
Total		2.0	26.0	257.0	.008	.101
Auto travel (Model: SR, PR, SA, RA)						
Public						
Benefit	No	101.6	15.3	469.5	.216	.033
Benefit	Yes	16.8	21.4	163.8	.103	.131
Risk	No	16.0	2.4	74.1	.216	.032
Risk	Yes	1.5	1.9	14.5	.103	.131
Total		135.9	41.0	721.9	.188	.057
Intervenors						
Benefit	No	78.7	4.6	114.3	.426	.040
Benefit	Yes	13.5	10.7	66.7	.202	.160
Risk	No	7.7	0.7	18.0	.428	.039
Risk	Yes	1.2	1.0	5.9	.203	.169
Total		71.1	17.0	204.9	.347	.083

(*table continues*)

TABLE 2 (continued)

Sample	Regulation acceptable	Activist status			Odds	
		Pro-S	Pro-B	No act	Pro-S/No act	Pro-B/No act
Nuclear weapons (Model: SR, PR, SA, RA, PA)						
Public						
Benefit	No	4.1	30.8	136.9	.030	.225
Benefit	Yes	.3	15.1	54.1	.006	.279
Risk	No	89.4	47.8	381.0	.235	.125
Risk	Yes	3.2	10.3	66.0	.048	.156
Total		97.0	104.0	638.0	.152	.163
Intervenors						
Benefit	No	2.3	13.1	30.9	.074	.424
Benefit	Yes	.3	11.1	21.1	.014	.526
Risk	No	50.3	20.3	86.1	.584	.236
Risk	Yes	3.1	7.6	25.8	.120	.295
Total		56.0	52.1	163.9	.342	.318
Industrial chemicals (Model: SR, PR, SA, PRA)						
Public						
Benefit	No	38.2	10.5	340.3	.112	.031
Benefit	Yes	2.0	2.5	34.5	.058	.072
Risk	No	89.8	2.8	376.2	.239	.008
Risk	Yes	–	–	8.0	–	–
Total		130.0	15.8	759.0	.171	.021
Intervenors						
Benefit	No	59.8	28.5	53.7	1.114	.531
Benefit	Yes	13.0	28.5	22.5	.578	1.267
Risk	No	54.1	3.1	22.8	2.373	.136
Risk	Yes	–	–	2.0	–	–
Total		126.9	60.1	101.0	1.256	.595

TABLE 2 (continued)

Sample	Regulation acceptable	Activist status			Odds	
		Pro-S	Pro-B	No act	Pro-S/No act	Pro-B/No act
		Nuclear power (Model: SR, PR, SA, SPA)				
Public						
Benefit	No	141.9	29.5	473.7	.300	.062
Benefit	Yes	6.1	20.0	88.3	.069	.227
Risk	No	21.6	1.6	33.7	.641	.047
Risk	Yes	.3	.4	2.3	.130	.087
Total		169.9	51.5	598.0	.284	.087
Intervenors						
Benefit	No	71.2	19.9	87.8	.811	.227
Benefit	Yes	8.8	40.1	47.2	.186	.850
Risk	No	17.2	–	.8	21.500	–
Risk	Yes	.8	–	.2	4.000	–
Total		98.0	60.0	136.0	.721	.441
		Handguns (Model: SPRA)				
Public						
Benefit	No	12.0	6.0	88.0	.136	.068
Benefit	Yes	11.0	33.0	75.0	.147	.440
Risk	No	142.0	12.0	524.0	.271	.023
Risk	Yes	12.0	4.0	46.0	.261	.087
Total		177.0	55.0	733.0	.241	.075
Intervenors						
Benefit	No	3.0	6.0	19.0	.158	.316
Benefit	Yes	9.0	22.0	22.0	.409	1.000
Risk	No	72.0	2.0	114.0	.632	.018
Risk	Yes	3.0	9.0	13.0	.231	.692
Total		87.0	39.0	168.0	.518	.232

Note. S = sample (public vs. intervenors); P = perception (more benefits vs. more risks); R = regulation (acceptable vs. not acceptable); and A = activist status (Pro-S = pro-safety; Pro-B = pro-benefit; No act = no action).

the public; for those who judged regulations as acceptable and those who did not; and for those who perceived more benefits than risks accrued, compared with those who felt otherwise. Intervenors were about twice as active as the general public in both pro-safety (.342/.152 = 2.25) and pro-benefit (.318/.163 = 1.95) actions. Those who judged the existing safety standards unacceptable were 6 times (.030/.006 = 6.25) more likely than those who judged them acceptable to take pro-safety actions; and those who perceived more risks than benefits in nuclear weapons were 10 times (.235/.030 = 10.37) more likely than those who perceived otherwise to take pro-safety actions.

Industrial chemicals. Intervenors, or those who had ever served as witnesses at a public hearing, were clearly more likely than the public to have taken actions in the issue of industrial chemicals: 7 times (1.256/.171 = 7.35) more likely in pro-safety activism and 28 times (.595/.021 = 28.33) more likely in pro-benefit activism. No one from the intervenor sample or from those in the general public who had taken any actions responded that he or she perceived more risks in industrial chemicals and found the safety standards acceptable at the same time. Thus, the relative levels of activism between different attitudes toward the existing regulations can be compared only among those who perceived more benefits in industrial chemicals. This is exactly what the three-way association (Perception × Regulation × Activism) specifies. Among those who perceived more benefits than risks, pro-safety activism was about twice (.112/.058 = 1.93) as high for those finding current regulations unacceptable as for those finding them acceptable. The reverse was true for pro-benefit activism; the odds ratio was approximately .4 (.031/.072 = .43).

Nuclear power. For both the intervenors and the general public, activism was affected by the assessment of existing safety standards regarding nuclear power. Those who found the standards unacceptable were 4 times (.300/.069 = 4.36) more likely than those who found them acceptable to take pro-safety actions. The reverse was true for pro-benefit activism (.062/.227 = .27). Because there was no one in the intervenor sample who perceived more risks in nuclear power and took pro-benefit actions at the same time, we must further specify by sample group the relative activism by perception of benefit/risk interaction. This requirement gives rise to the three-way interaction of Sample × Perception × Activism. For the general public, those who perceived more risks than benefits were twice (.641/.300 = 2.14) as likely as those who perceived more benefits than risks to take pro-safety actions. The reverse again was true for pro-benefit activism (.047/.062 = .76). For the intervenors, those who perceived more risks in nuclear power were 26 times (21.500/.811 = 26.32) more likely than those who perceived more benefits to take pro-safety actions. However, no similar comparison can be made for pro-benefit activism, as there was no one among the intervenors who perceived more risks and took pro-benefit actions at the same time.

Handguns. The fact that the four-way table for handguns was not reducible to a simpler model suggested that perceptions, sentiments, and activism were the most diverse and controversial among the general public and the intervenors on this issue. For the public, pro-safety activism was almost equally likely for those who judged the existing standards unacceptable and those who judged them acceptable—an odds ratio of about 1.0 (.136/.147 = .93; .271/.261 = 1.04). This likelihood of pro-safety activism by the public was true for the entire range of perceptions of the risks and benefits of handguns. For intervenors, on the other hand, the perception of the risk/benefit ratio made a clear difference. Those who perceived more risks than benefits and who judged the existing regulations unacceptable were nearly three times (.632/.231 = 2.74) as likely as those who judged them acceptable to take pro-safety actions. Intervenors who perceived more benefits and judged the regulations unacceptable were, by comparison, less likely to act for safety than those who judged the regulations acceptable (.158/.409 = .39). On pro-benefit activism, generally those who regarded the existing regulations unacceptable were less likely to act for benefits. However, this contrast seemed most distinct among intervenors who perceived more risks than benefits in handguns—an odds ratio of .03 (.018/.692 = .03).

Summary and Future Research

In terms of the relative likelihoods of taking pro-safety or pro-benefit actions, as measured by the odds and odds ratios calculated in the present analysis, intervenors were significantly higher than the general public for all six technologies investigated. Intervenors were also less likely than the public to find the existing regulations of these technologies unacceptable. For both the public and the intervenors, the assessment of the acceptability of existing regulations did make a significant difference in whether they assumed an activist status. The perception of a technology's benefits and risks directly affected the assessment of the acceptability of existing safety standards, and thus these perceptions affected activism, at least indirectly.

Except for handguns, in which the public's and intervenors' perceptions, acceptability assessment, and activism status were most diverse, the patterns of variable associations of the other five technologies investigated were not difficult to discern. For industrial chemicals and nuclear power, where a significant three-way variable association was found, the third variable specification was necessary simply because there were null cells in the four-way contingency table (e.g., perceiving more risks than benefits in a technology while taking pro-benefit action at the same time); this situation made comparisons of relative likelihoods invalid.

The issue of little or no consistent attitude–behavior correspondence, often reported in social psychological research, can be both a conceptual and a methodological anomaly. Conceptually, one might suspect whether the selected attitudinal variables derived from a theoretical framework are relevant determinants of people's behavior "in real life." Methodologically, there could be endless debate on, for example, how to measure behavior (by respondents' self-reported actions or by actual behavior objectively observed) or how specific or comprehensive action items should be included in measuring a behavior under study? Regarding comprehensiveness in selecting action items, as Weigel and Newman (1976) eloquently and convincingly demonstrated, when a behavioral measure is broad in its scope—the statistical variation of the measure is thus enlarged—the correlational measure of attitude–behavior correspondence can usually be vastly increased.

More relevant to this research is an earlier study by the same group of authors (Gardner et al., 1982) that served as a springboard to their expanded study project, reported in Gould's (1988) book. In that earlier study, the authors focused on nuclear power only, and they used a nonrandom sample with an overrepresentation of highly educated, expert subjects. Unlike a representative sample of the general public, this particular sample generated sufficient variation in each of the measured variables (perceptions of risks and benefits, attitudes toward safety regulations, and actions taken regarding safety of nuclear power). Because the authors used correlational analyses, their results were far less ambiguous than those in their later study (which was extended to six technologies and used an expanded random sample of intervenors and the general population). Their conclusion, then, was succinct:

> Among the most important are its judged acceptability (both in terms of desired restrictions and standards and desired level of deployment). . . . Action is directly influenced, but to a lesser extent by the perceived risks and benefits of nuclear power and perhaps also by qualitative risk and benefit characteristics and fatality estimates; these variables are primary determinants of judged acceptability and they thus have an additional, indirect influence on action. (Gardner et al., 1982, p. 196)

This conclusion regarding perceptions, attitudes, and actions concerning nuclear power is remarkably consistent with the path model in Figure 1, which summarizes our findings with respect to all six technologies in the present re-analysis. The strategy of investigating relative likelihoods (odds and odds-ratios in the log-linear model analysis, in this case) rather than using variance–covariance analyses proves to be fruitful when the initial variation in some of the variable measures is quite small.

Attitudes of acceptability of safety standards is clearly the most direct determinant of activism in influencing technological risk management; the next research issue should focus on the acceptability of safety standards as a dependent variable. Gould and his associates (1988) considered the general attitude favoring regulations stricter than the existing standards for most of the six technologies an anomaly. Such attitudes, however, could hardly be differentiated consistently by sociodemographic or general attitudinal variables, including political persuasions, liberal or conservative.

Nevertheless, we suspect that assessing the acceptability of safety standards (also a small-variance variable in the survey data used) and the associations of this variable with other variables may have been overlooked when the researchers used analytical techniques such as correlation–regression statistics. A re-analysis with a log-linear approach can be easily carried out to verify the previously reported results of Gould and his associates. Nonetheless, more than simple methodology seems to be involved in conceptualizing people's attitudes toward a technology's safety regulations and in conceptualizing the interrelationships of attitudes with perceptions of the technology's benefits and risks and with consequent actions.

Two important results emerged from the data, as re-analyzed in the present research: (a) The concern for safety regulations was a stronger determinant of action and type of action than risk perception was, and (b) the intervenors were more likely than the general population to consider current safety regulations acceptable (regardless of technology), and to express pro-technology attitudes and to act and agitate toward these goals.

Recent research on risk communication has shown that concern for adequate safety regulations indicates a wish (and need) for control of risks involved in the use of technologies. Control has been recognized as a health-promoting and healthy-maintaining force for nonenvironmental health risks (Appels & Steptoe, 1989; Fitzpatrick, Neuman, Lamb, & Shipley, 1990; Lefcourt & Davidson-Katz, 1991; Ormel & Schaufeli, 1991; Siegrist & Matschvinger, 1989; Syme, 1991). Control has also been discussed in the literature on stress (Antonovsky, 1985; Averill, 1973; Lazarus & Folkman, 1984; Monat, Averill, & Lazarus, 1972; Tomas & Stallen, 1981). In contrast, the need to "feel safe" with respect to risks associated with technology use has only recently begun to command more attention (Karger, Schuetz, & Wiedemann, 1992; Kennedy, Probart, & Dorman, 1991; Ruff, 1993; Schuetz & Toennis, 1991). However, the need to feel safe is still rarely considered as the decisive factor influencing risk perception and risk-related behavior (see Hazard, 1993). We suggest that there is a need for control, which, for collectively controlled risks, expresses itself in safety regulations. For individually controlled risks, the possibility of adopting health protective behavior communicates a sense of control (Hazard).

The need for control exists equally for both intervenors and the public at large. Those who hypothesize that experts use quantitative and objective criteria to define the extent of risk and that the lay public uses qualitative and subjective criteria seem to miss an important point. An alternative hypothesis, suggested by our data, may be that the frequently observed discrepancy between the experts' and the public's view is due, to a large extent, to the different locations and cognitive distance of each party from safety measures. For collectively controlled risks, politically and scientifically active experts are more knowledgeable about the safety regulations and also may be directly involved in their implementation and monitoring (e.g., for nuclear power, nuclear weapons, and industrial chemicals).

The public is less knowledgeable and more distant (see Evers & Nowotny, 1987, an analysis of Kaufmann, 1973). Conversely, for risks involving safety regulations that ultimately must be carried out by the public, the experts may feel less in control than the public does, (e.g., auto travel, handguns).

The direction of causal relationships originally assumed by Gould et al. (1988) is possibly the reverse (note that those directional arrows appearing in Figure 1 may be oversimplifications; feedback effects between variables are conceivable). The estimation of degree of control via safety regulations may affect the perception of the amount of risk at hand. Thus, the original view that the amount of risk is determined solely by the calculation of the amount of benefits must be revised to include the calculation of the amount of protection from risks. This calculation may indeed be the more important determinant of risk perception (Mazur, 1987). According to our analysis, the experts considered the collectively controlled risks to be better controlled than the public considered them to be, and the experts also considered the technology less risky than the public did. The opposite held true for those technologies (auto travel and handguns) with which the public plays a more immediate role in guaranteeing safety. For these two technologies, the experts had a higher risk perception than the public did.

The consideration of safety regulations is not the only determinant of the decision to act or the direction of action. Additional preconditions are (a) knowledge of possibilities and feasibility of action (for air travel, there was a logic of judging safety standards inadequate, but increasing demands for safety were too expensive) and (b) the self-estimation that one is competent and capable of acting (self-competency, also often called self-efficacy). Therefore, the model must be supplemented and expanded in future research.

The implications of these findings for risk communication are that just being informed about risks is not adequate; one must also be informed about resources for protecting oneself against these risks. In addition, a sense of self-competency must be communicated; such communication is possible only when individuals are permitted to participate in the decision-making process. These aspects of risk-communication research are just beginning to be considered more systematically. Our data confirm that more work should be done in this direction.

REFERENCES

Antonovsky, A. (1985). *Health, stress and coping.* San Francisco: Jossey-Bass.

Appels, A. & Steptoe, A. (Eds.). (1989). *Stress, personal control and health.* Brussels: Wiley.

Averill, J. (1973). Personal control over aversive stimuli and its relationship to stress. *Psychological Bulletin, 80*(4), 286–303.

Evers, A., & Nowotny, H. (1987). *Über den umgang mit unsicherheit* [On handling insecurity] (pp. 23–26). Frankfurt, Germany: Suhrkamp.

Fitzpatrick, R., Neuman, S., Lamb, R., & Shipley, M. (1990). Helplessness and control in rheumatoid arthritis. *International Journal of Health Sciences, 1,* 17–23.

Gardner, G. T., Tieman, A. R., Gould, L. C., DeLuca, D. R., Doob, L. W., & Stolwijk, A. J. (1982). Risk and benefit perceptions, acceptability judgments, and self-reported actions toward nuclear power. *The Journal of Social Psychology, 116,* 179–197.

Gould, L. C., Gardner, G. T., DeLuca, D. R., Tieman, A. R., Doob, L. W., & Stolwijk, A. J. (1988). *Perceptions of technological risks and benefits.* New York: Russell Sage Foundation.

Hazard, B. (1993). *Information und beteiligung bei gesundheitsrisiken am beispiel eines radonmeßprogramms* [Information and participation in coping with health risks—the case of a radon testing program]. New York: Fischer.

Karger, C., Schuetz, H., & Wiedemann, P. M. (1992). *Akzeptanz von komaschutzmaßnahmen in der Bundesrepublik Deutschland* [Acceptance of climate-related protective measures in the Federal Republic of Germany] (Vol. 30). Jülich, Germany: Forschungszentrum Jülich GmbH.

Kaufmann, F. X. (1973). *Sicherheit als soziologisches und sozialpolitisches problem* [Security as a sociological and sociopolitical problem]. Stuttgart: Fischer.

Kennedy, C. J., Probart, C. K., & Dorman, S. M. (1991). The relationship between radon knowledge, concern, and behavior, and health values, health locus of control and preventive health behaviors. *Health Education Quarterly, 18*(3), 319–329.

Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal, and coping.* New York: Springer.

Lefcourt, H. M., & Davidson-Katz, K. (1991). Locus of control and health. In C. R. Snyder, & D. R. Forsyth (Eds.), *Handbook of social and clinical psychology. The health perspective* (pp. 246–266). New York: Pergamon.

Mazur, A. (1987). Does public perception of risk explain the social response to potential hazard? *Quarterly Journal of Ideology, 11,* 41–45.

Monat, A., Averill, J. R., & Lazarus, R. S. (1972). Anticipatory stress and coping reactions under various conditions of uncertainty. *Journal of Personality and Social Psychology, 24*(2), 237–253.

Ormel, J., & Schaufeli, W. B. (1991). Stability and change in psychological distress and their relationship with self-esteem and locus of control: A dynamic equilibrium model. *Journal of Personality and Social Psychology, 60,* 288–299.

Ruff, F. (1993). Risikokommunikation als aufgabe für die umweltmedizin [Risk communication as a task for environmental medicine]. In K. Aurand, B. Hazard, & F. Tretter (Eds.), *Umweltbelastungen und Äengste* (pp. 327–364). Opladen: Westdeutscher Verlag.

Schuetz, H., & Toennis, W. (1991). *Individuelles entsorgungs-verhalten und akzeptanz von entsorgungstechnologien* [Individual disposal behavior and acceptance of disposal technologies] (Vol. 22). Jülich, Germany: Forschungszentrum Jülich GmbH.

Siegrist, J., & Matschvinger, H. (1989). Restricted status control and cardiovascular risk. In A. Steptoe & A. Appels (Eds.), *Stress, personal control and health* (pp. 65–82). Chichester & New York: Wiley.

Syme, S. L. (1991). Control and health: A personal perspective. *Advances, 7,* 16–27.

Tomas, A., & Stallen, P. J. M. (1981). *Risk, stress and decision-making.* Paper prepared for the Conference on Subjective Utility and Decision-Making, Budapest.

Weigel, R., & Newman, L. (1976). Increasing attitude-behavior correspondence by broadening the scope of the behavioral measure. *Journal of Personality and Social Psychology, 33,* 793–802.

Received September 27, 1993