International Journal of Mass Emergencies and Disasters
November 1990, Vol. 8, No. 3, pp. 207-235

IGNORANCE AND DISASTERS

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While ignorance has long troubled efforts to prevent, prepare for, or manage the aftermath of disasters, relatively little work has been done on the specific varieties of ignorance and the roles they play in disasters. The classical frameworks for decision-making under "uncertainty" are too restrictive, and many prescriptions for disaster management simply call for better communication or more data collection by way of reducing ignorance. Unfortunately, in connection with disasters, ignorance often is irreducible. This article presents a framework for understanding the various kinds of ignorance, and utilizes that framework to provide some insights and tools that may improve disaster preparedness, management, recovery, and learning.

FACING UP TO AND LEARNING FROM IGNORANCE

If we are to learn from disasters (Dynes 1988, p. 107), then we must be able to represent, analyse, and communicate about our ignorance as well as our knowledge. This stipulation entails rejecting the much-used option of "editing out" our uncertainties, missing information, and mistaken perceptions when comes the time to act or make decisions. It also requires that we not indulge in the opposite convention of crying total ignorance by way of justifying inaction in the face of any kind of uncertainty.

There are several reasons for attempting an overview of ignorance in the context of disasters. An obvious justification is that disasters seem to be associated with either unexpected events or mistaken perceptions. Most writers in the field characterize disasters in terms of risk. Turner goes as far as to claim "disaster equals energy plus misinformation" (1978, p. 189), and Meyer (1982) uses the phrase "environmental jolt" for a similar description. A somewhat more far-reaching reason is that individual and organizational responses to disasters may lend insights into responses to mundane ignorance and/or risk. Quarantelli (1987) declares that not only is there no need for special or unique explanations for disasters (thereby echoing similar recent claims in the sociological literature on deviancy), but also disaster research has contributed much to explaining ordinary social life. A third justification arises from the growing agreement across a number of disciplines and professions that traditional means in Western culture for eliminating or evading uncertainty are no longer sufficient. We cannot avoid having to make decisions or acting under uncertainty, or even total ignorance (cf. Collingridge 1980). Therefore, any sustainable strategy for dealing with disasters must incorporate adequate methods for decision-making and managing under ignorance.

The frameworks we use to represent and assess ignorance are crucial to the entire enterprise. Issues such as whether (or how) to quantify ignorance, what is "rationality," and how people perceive ignorance must be carefully assessed. Traditionally, uncertainty has been represented via probability theory or approximations thereof. Such an approach is prescriptive rather than descriptive, and it ignores psychological, social, and cultural factors. Given the widespread use of sociological (and especially structural and organizational) approaches in the study of disasters, a sociological approach to understanding the nature and role of ignorance in disaster ought to be attempted.

This article takes a more radical stance (which will be articulated in the next section). Ignorance, like knowledge, is primarily a social creation. Ignorance is generated and used by real people in real institutions; it is not merely a pre-existing feature of the nonhuman environment. We need a better description of how and why various kinds of ignorance become built into our organizational technostructure, and how people respond to those constructions, to complement our prescriptive perspectives. This article addresses both of these concerns, although by no means exhaustively. My intentions are threefold: (1) to propose a social scientific framework for studying ignorance; (2) to make some semi-prescriptive recommendations for how various types of ignorance may be represented in disaster management and research; and (3) to discuss the sources and consequences of particular kinds of ignorance in the context of disaster preparations, onset and response, and recovery.

A SOCIOLOGICAL FRAMEWORK FOR IGNORANCE IN DISASTERS

Ignorance usually is treated as either the absence or the distortion of "true" knowledge, and uncertainty as some form of incompleteness in information or knowledge. To some extent these commonsense conceptions are reasonable, but they deflect attention away from ignorance by defining it indirectly as **non**-knowledge. Ignorance is itself a social creation, like knowledge. We cannot even talk about particular instances of ignorance without referring to the standpoint of some group or individual. Ignorance, like knowledge, is socially constructed and negotiated.

The socially based perspective on ignorance presented here is taken from Smithson (1989a). In that framework, ignorance is defined as follows: "A is **ignorant** from B's viewpoint if A fails to agree with or show awareness of ideas which B defines as actually or potentially valid." This definition avoids the absolutist problem by placing the onus on B to define what she or he means by ignorance.It also permits self-attributed ignorance, since A and B may be the same person. Most importantly, it incorporates anything B thinks A could or should know (but doesn't) and anything which B thinks A must not know (and doesn't). B may be a perpetrator as well as an attributor of ignorance.

A second major pitfall in conventional approaches to ignorance is to view it as unitary. Ignorance is multiple, and has distinct levels. Some such distinctions have been known for some time. For instance, the person in self-confessed error believes that he doesn't know, while the ignoramus is unconscious of his lack of knowledge. The first may be called conscious ignorance and the second meta-ignorance (cf. Smithson 1985).

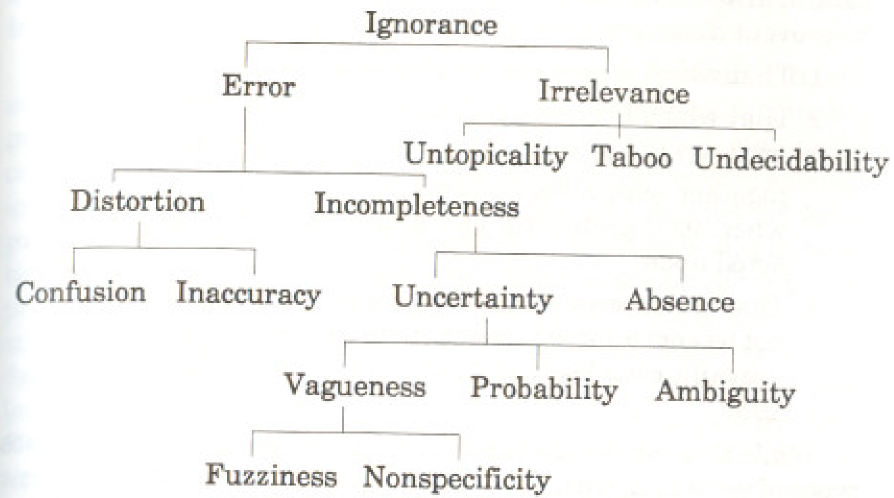
The most important distinctions are those which refer to different kinds of ignorance, rather than different levels or loci. Another commonsense distinction which arises in common language is between "ignoring" (active voice) and "being ignorant" (passive voice). This duality is fundamental and therefore is an appropriate first branching point in a typology of ignorance. The act of ignoring is a declaration of **irrelevance**, which is the term I will use to refer to this kind of ignorance. The state of ignorance, on the other hand is in one way or another an erroneous cognitive state, and I will refer to it by the term **error**. These two terms parallel Turner's (1978) concepts to some extent.

Error may arise from either incomplete or distorted views (or both, of course). **Distortion** usually is referred to in terms of "bias" or "inaccuracy," on the one hand, and "confusion" on the other. The former refers to distortion in degree while the latter indicates wrongful substitution in kind. **Incompleteness**, on the other hand, has received the most attention in most fields which purport to deal with "uncertainty," quite possibly because it seems more corrigible than distortion (these two terms parallel "neglect" and "distortion" in Weinstein and Weinstein 1978). However, uncertainty is a less inclusive term. Incompleteness in kind will be termed **absence**, while incompleteness in degree will be called **uncertainty**. Uncertainty, in turn, includes such concepts as probability, vagueness, and ambiguity.

Turning now to irrelevance, the most obvious kind is **untopicality**. For our purposes, it refers to the intuitions people carry with them and negotiate with others about how their cognitive domains fit together. Folk-wisdom lauds geniuses for their avowed capacity to see connections between matters that appear irrelevant and unrelated to most people. However, a similar attribution is made about the insane.

There are two other kinds of irrelevance that pertain to our typology: **undecidability** and **taboo**. Undecidability is attributed to those matters which people are unable to designate true or false either because they consider the problem insoluble or because the question of validity or verifiability (or perhaps even meaning) is not pertinent. Taboo, on the other hand, is socially enforced irrelevance. Taboo matters are literally what people must not know or even inquire about. Taboos function as guardians of purity and safety through socially sanctioned rules of (ir)relevance. This concept is particularly rich in its explanatory power for how we deal with anomalous or cognitively threatening material, and social anthropologist Mary Douglas places her concerns with taboos in the center of any explanation concerning how we deal with disorder. As she points out (Douglas 1966, p. 39), any system for cognitively ordering the environment gives rise to anomalies, and all cultures must therefore confront these anomalies with appropriate strategic defenses.

Figure 1. Taxonomy of Ignorance



The complete taxonomy is displayed in Figure 1. For a further elaboration of it, see Smithson (1989a). Let us return briefly to the topic of uncertainty, which I have not discussed yet and which has been allocated a low position in the above figure despite its predominance in several fields. In some fields, the term is employed as a synonym for ignorance. It should be clear by now however, that uncertainty is not as broad a concept, even though it is the home of probability theory and several other newer normative approaches to ignorance.

Uncertainty is subdivided into vagueness, probability, fuzziness, nonspecificity, and ambiguity. These labels correspond with fairly widespread usages in both philosophical and scientific literature. This is not the only way to subdivide uncertainty. However, most other taxonomies (e.g., Howell and Burnett 1978 or Kahneman and Tversky 1982) are based on well known probabilistic concepts.

Most writing on disasters, like so many other areas, treats ignorance as if it were unitary and indiscriminately refers to terms such as uncertainty, ambiguity, and vagueness as if they are synonymous. However, Turner and a few other writers in the disasters and hazards fields refer to at least three senses of ignorance included in the taxonomy: incompleteness (often called "uncertainty"), distortion (Turner calls this "misinformation"), and irrelevance (overlooking, ignoring or discounting relevant information). Turner's classification of information which would be needed to prevent disasters includes the following:

1. That which is completely unknown.
2. That which is known but not fully appreciated.
3. That which is known by someone, but is not brought together with other information at an appropriate time when its significance can be realized and its message acted upon.
4. That which was available to be known, but which could not be appreciated because there was no place for it within prevailing modes of understanding. (Turner 1978, p. 195-196)

While this list includes several worthwhile points, it juxtaposes types of ignorance with issues such as who knows or does not know and whether available information is being correctly processed or understood. The list also has an atemporal quality to it, and seems to refer primarily to the onset and prevention of disasters. Drabek's (1986) stage model of disasters and system response (preparedness, response, recovery, and mitigation) cues us to ask whether certain kinds of ignorance are more pertinent to one stage than another. These issues should be separately analyzed where possible.

In the next section, we shall discuss the representation of various kinds of ignorance and its implications for disaster management. The representation of ignorance is probably most important for the preparedness and mitigation or post-disaster learning phases, since it involves encoding the state of our (lack of) knowledge. The opportunities for such encoding exercises are far more likely to arise before and after a disaster.

ISSUES IN IGNORANCE REPRESENTATION AND ASSESSMENT

The Fallacy of False Precision

When data are only partly incomplete (i.e., vague and/or ambiguous) or even distorted, there is a tendency to represent them as if they were nevertheless precise. To some extent, this practice merely arises from what I.J. Good (1962) called a "mathematical convenience." But there is also plenty of circumstantial and experimental evidence (cf. Ellsberg 1961, and Einhorn and Hogarth 1985) that under many conditions people prefer and expect precise information from experts or authorities.

Unfortunately, once uncertain data are encoded into a knowledge base in precise form, they are also analyzed as if they are precise. The summary statistics (means, frequencies, etc.) based on them do not include an explicit representation of incompleteness or distortion. I shall refer to this practice as a **fallacy of false precision**. False precision implies that requests for a single-number (pointwise) estimate of even a tangible parameter are inappropriate. For example, depending on source, the Bhopal accident is said to be responsible for somewhere between 2700 and 8000 deaths (Wilkins 1989, p. 21); and Chernobyl produced cancer-related risks which scientists estimate will cause anywhere from 5000 to 500,000 more deaths (Lowe 1990). It would be ludicrous to summarize these conflicting, wide-ranging estimates by a pointwise midpoint, mean or median.

Let us begin by considering the simple absence of information. The traditional means for handling missing data indulge in false precision, either through using pointwise estimates of the missing values or by compensating for them with pointwise weights and treating the reduced data-set as if it is precise and complete. In the statistical and social sciences, missing data are treated in two ways. Either they are eliminated from the analysis (and N reduced accordingly), or they are estimated on the basis of existing data. Either way, sample estimations of population parameters must then be constructed in ways which compensate for selective absence of data (cf. Kalton 1983). While there are some statistical justifications for these approaches, each increases the likelihood that missing data will simply be ignored or processed unconsciously by decision makers. In short, they invite meta-ignorance. The reason is simple: pointwise summary statistics based on incomplete data look exactly the same as those based on complete data, because the uncertainties associated with incomplete data are not explicitly represented in the summary statistics. Moreover, by merely "compensating" for incomplete data, researchers and policy makers fail to take account of the circumstances under which information is most likely to go missing or be unavailable. The traditional statistical treatment of missing data is predicated on the assumption that its occurrence is randomly distributed throughout some specified subset of the knowledge base. However, as any experienced data collector knows, the distribution of incomplete information seldom is random or evenly spread across important factors. Data are most likely to go missing when:

1. Conditions or cases are unusual, anomalous, or nonrepresentative.
2. The object of scrutiny is complex.
3. Observation and/or data-processing are expensive or difficult.
4. Time is short.
5. The object of scrutiny has low saliency, low value or importance, or low relevance to those who are gathering the data.
6. The object of scrutiny is taboo, secret, off-limits, or could discredit those in control of data-gathering (this includes bans on revealing the extent of ignorance about the object, as per Janis (1972)).
7. The object of scrutiny is reluctant to be observed.
8. Communication is poor, blocked, or misdirected.
9. Data gathering, collation, and processing are uncoordinated.

It might be tempting to assume that these circumstances apply mainly to disaster-like situations and not, for example, to data gathered under "normal" conditions. Such a view is implicit in most research in disasters and other fields which makes use of official statistics (e.g., census data, accident rates, or crime statistics). Unfortunately, there are good reasons for abandoning this assumption. In many economic surveys in developed Western nations, for instance, non response rates on mundane questions about income range from about 25% to 40% and these have increased during the past two decades (Feige 1989, p. 35).

There is also an understandable motivational basis for ignoring or even concealing how incomplete our knowledge bases are. Researchers may wish to avoid appearing less than fully informed or thorough when presenting their findings to colleagues, policymakers, or the public. Policymakers, on the other hand, may well assume that nonrespondents to public opinion surveys or other political information-gathering exercises are not important. For

them, as Alford and Feige (1989, p. 72) point out, non response connotes either satisfaction or apathy, neither of which is politically threatening. Nevertheless, failing to make missing data salient does not mean that decision makers will be unaffected by it. Studies of decision making under incomplete (as opposed to merely uncertain) information suggest that incompletely specified alternatives are devalued in favor of fully described ones (Yates et al. 1978), and that inferior options may be selected because some information is missing (Barron 1987). Moreover, Levin and his colleagues (1985, 1986) have experimentally reproduced some of the framing effects on judgment found in studies of judgment under probabilistic uncertainty for tasks in which information required for a decision is missing. These effects indicate that we may be better off if the extent of incompleteness in our information is explicitly represented and analyzed where feasible.

Researchers and policy makers alike are even more vulnerable to distorted data, which is a considerably more difficult problem than mere incompleteness. It is well known that people are more likely to distort in self-disclosures when those disclosures are linked to self-evaluation, assessment by others, legal liability, or other more tangible consequences. Less well known, however, is the possibility that self-reinforcing feedback loops between researchers, respondents, and policymakers may generate false trends in official statistics which have profound policy implications.

Alford and Feige describe some of the hypothetical consequences arising from an economy whose total growth-rate is normal and constant, but whose unobserved (i.e., hidden, illegal, or off-the-books) sector grows more rapidly than the observed sector. As the observed sector becomes a smaller portion of the total economy, official statistics will understate growth-rates and these in turn will decline, falsely signalling a recession. Simultaneously, consumer price indexes will overstate the true price level and unemployment rates also will become artificially inflated. Governmental responses to these apparent signs of an economy in recession will include higher wage awards, social security benefits, and retirement payouts, all of which will increase the tax burden, and so on (cf. Alford and Feige 1989, p. 66-67). Expectations of stagflation, in short, will induce policies and decisions that actually bring on stagflation because this is a positive feedback loop rather than a self-correcting one.

Incomplete as it is, this catalog of circumstances and consequences nevertheless provides compelling reasons for those in disaster management and research to monitor, encode, and analyze the circumstances and reasons contributing to incomplete information. Not only would that contribute to an honest appraisal of preparedness, but also to the assessment of information gathering priorities after a disaster has occurred. It is also worth noting that, as Mileti (1987) points out, some of the barriers militating against information availability may come down during a disaster. He claims that response rates to surveys are generally higher than under nondisaster conditions, and that sometimes organizations become more willing to disclose and permit access to privileged information. These opportunities cannot be effectively seized unless the gaps in knowledge are already recorded, effectively represented, and strategically taken into account.

Encoding and Representing Ignorance

Rather than providing a survey of the available techniques and frameworks for representing different kinds of ignorance (for one overview, see Smithson 1989a), this section focuses on the application of those frameworks to research on disasters and related phenomena. It also briefly outlines the major debates and problems involved in such applications. Let us begin with a representative case-in-point, a brief description of a tornado which struck West Memphis in Arkansas on December 14, 1987:

> ... a tornado <u>of significant proportions</u> touched down without warning in the <u>south central portion</u> of West Memphis, Arkansas. Winds were estimated at <u>150-200 mph</u>, and measuring the breadth of <u>approximately a city block</u>. The tornado travelled **northwest** at <u>about 60 mph</u> through the <u>southern residential, central business, and northeastern residential districts</u> ... was on the ground a <u>minimum of 14 minutes</u> as it passed through the city.... Six persons were killed, **some 45 persons** were admitted into the local hospital for **serious injuries**, and a total <u>of about 125</u> persons were treated at the emergency room as a result of the tornado. Initial estimates ... suggested property damages in <u>excess of $20 million</u>, although later estimates were <u>closer to $35 million</u>....(Faupel 1988, p. 185)

The emphases are mine, and they highlight several kinds of uncertainty and several different methods for representing them. <u>Underlined</u> phrases indicate uncertainties, while the **bold** phrases indicate information that is possibly falsely precise. This example is descriptively rich insofar as it employs a variety of verbal and numerical representations of vagueness, ambiguity, and even inaccuracy.

At the very least, we should be able to use the taxonomy in Figure 1 to equip disaster researchers with a minimal toolkit for tagging pieces of information such as those given Faupel's description with an appropriate label for the kind(s) of ignorance attached to them. One such toolkit may be constructed by translating each level of the taxonomy into labels denoting various attributes applicable to missing data. There are at least the following kinds of missing data:

1. **Irrelevant**: Information is missing because it is considered either untopical (inapplicable), taboo, or undecidable (unintelligible).
   - 1.1. **Untopical**: The information is considered inapplicable or unimportant.
   - 1.2. **Taboo**: Information source refuses to divulge information, and/or researchers will not obtain it (for ethical or whatever reasons).
   - 1.3. **Undecidable**: Information is unintelligible or so novel as to fall outside current frameworks for interpreting the information.
2. **Erroneous**: Information is missing because of limited understanding, even though it is considered applicable and/or important.
   - 2.1. **Incomplete**: Information is unavailable or only partly available.
     - 2.1.1. **Absent**: Information is unavailable.
     - 2.1.2. **Uncertain**: Information is available but is vague, ambiguous, etc.
   - 2.2. **Distorted**: Information is inaccurate or confused.

2.2.1. **Inaccurate**: Information is "disinformation," whether through lying or inaccurate assessment.

2.2.2. **Confused**: Information appears to be the product of misunderstanding or outright confusion.

Clearly the minimal representation of ignorance will label pieces of "missing" information either as **irrelevant** or **erroneous**. The next level of resolution involves five possible labels, and so on.

Qualitative distinctions are a first step in assessing ignorance. The next step clearly is representing the degree of particular kinds of ignorance, preferably in such a way as to be able to combine and analyze that information. Because uncertainty is the most widely debated kind of ignorance, we may start at the bottom of the ignorance taxonomy in Figure 1 and consider alternative approaches to representing various kinds of uncertainty. The example provided above makes one such choice obvious, namely whether to use words or numbers in expressing uncertainty. Until recently, the debates over whether to use words or numbers has been hampered in two ways. First, it has dealt almost solely with probabilistic uncertainty. Second, the basis for comparisons between verbal and numerical expressions of probability has been confined to using pointwise numerical probabilities.

This latter restriction led many researchers to conclude that the translation between verbal expressions of probability and precise numerical probabilities is at best idiosyncratic and context-dependent (e.g., Lichtenstein and Newman 1967, Beyth-Marom 1982, and Pepper and Prytulak 1974), and that judgments using numbers are generally superior to those employing words (e.g., Behn and Vaupel 1982, and Nakao and Axelrod 1983). More recently, however, several researchers have realized that verbal probability expressions (e.g., "somewhat likely") are best considered as referring to "fuzzy" probabilities. Wallsten et al. (1986) and Zimmer (1984), among others, have pioneered studies in which subjects are asked to construct fuzzy membership functions over the [0,1] interval to correspond with verbal expressions of this kind. These membership functions take values of 0 for probabilities not at all consistent with the phrase, 1 for probabilities entirely consistent with it, and intermediate values otherwise.

Several studies have since been conducted by Wallsten and his colleagues comparing peoples' performance in judgment and decision making using verbal and corresponding fuzzy numerical expressions of probabilistic uncertainty. It is not within the scope of this paper to review that research here. In contrast to the pro-numerical tone of earlier research, some of the more recent researchers have found in favor of verbal expressions (Nagy and Hoffman 1981, and Zimmer 1983, 1984). However, Wallsten's (forthcoming) own up-to-date review points out that overall, the findings of the best studies point to remarkably few differences in the quality of judgments or decisions between those who use words and those using numbers. Some evidence, however, does suggest marked preferences on the part of subjects for expressing probabilistic uncertainty in verbal terms but receiving information on probabilistic uncertainty in numerical terms.

The upshot of all this seems to be that the representation of probabilistic uncertainty is problematic when it is not amenable to being expressed by precise (pointwise) numerical probabilities, i.e., when those probabilities are vague. The choices currently argued for by various writers include verbal expressions, numerical possibility intervals (or fuzzy membership functions as their generalized version), and confidence intervals (or second-order probability distributions as their generalized version). Moreover, as risk analysts such as Hattis (1989, p. 122) observe, the question of what kind of representation to use may hinge on the questions that are deemed most important, affordable, or relevant by those assessing uncertainty. Expressions of probabilistic uncertainty will be in good part determined by whether the goal is to find **best estimates**, the likelihood of **worst-case** events, **conservative** versus **liberal** estimates of risk, and so on.

Finally, there are communicative purposes to be considered as well. Words are easier for lay people to understand, but numbers are more explicit and less context-dependent. Numbers also however, may appear falsely precise, especially if only pointwise estimates are used. A claim that the probability of a nuclear reactor core meltdown during a given year is 10^{-5} seems to carry quite a different message from one which conveys the additional information that a 95% confidence interval around that estimate has an upper bound of 0.14 (cf. Kalbfleisch et al. 1982, p. 20-22). Moreover, there are a variety of framing effects that arise from the context in which either numerical or verbal expressions of uncertainty are embedded (cf. Tversky and Kahneman 1981, among many others). For a thoughtful and prescriptive discussion of risk communication, albeit one limited by its restriction to probabilistic risk analysis, see the manual for plant managers in Covello et al. (1989, p. 297-357).

If we move now to the representation of vagueness, we find that until recently the only available modes of expression were verbal phrases or simple numerical intervals (as in our example above). During the last 25 years, however, fuzzy set theory has evolved as a serious candidate for linking verbal and numerical expressions of vagueness (Zadeh 1965, but see Dubois and Prade 1980 for a survey of applications in engineering, or Smithson 1987 for an overview oriented towards the behavioral and social sciences). Fuzzy set theory may be viewed as a far-ranging generalization of numerical intervals for representing vague quantities, but it also is able to handle categories with blurry boundaries.

An allied development for expressing a looser kind of uncertainty than probability is possibility theory (Zadeh 1978, but see Dubois and Prade 1988 for an overview and Smithson 1988 for a discussion of applications to psychology). A numerical degree of possibility for an event places an upper bound on the probability of the same event. While the mathematics of possibility theory are straightforward and the expression of possibilities in numerical terms certainly has application in the study of risk and/or disaster scenarios, possibility theory also opens up some difficult questions for would-be rational decision makers. As Podesta and Olson (1988: p. 312) put it, "...what actions should government order when the scientific state of the art can only specify something between a possibility and probability?" The point here is, however, that possibility theory at least enables us to avoid the trap of false precision by not misrepresenting possibilities as probabilities.

Although still controversial, the primary attraction of fuzzy set and possibility theories is their expressive capabilities for elaborate expressions of vagueness in conjunction with analytically powerful machinery for combining and manipulating those expressions. Fuzzy set theory is fairly well-suited for addressing such questions as how high a windspeed and how large an area a tornado must possess in order for it to be a tornado of "significant proportions." Both of these frameworks are worth using in disaster research and policy formulation.

Ambiguity, in contrast, has received rather little attention. The term often is used as if it is synonymous with other kinds of uncertainty, but Black (1937) made an excellent case for preserving the distinction between ambiguity and concepts such as vagueness. Ambiguity entails multiple possible interpretations of a piece of information (e.g., "the food is hot" could refer to high temperature or spiciness), and so ambiguous data are those which possess multiple possible images. In disasters, perhaps the most common example of ambiguity comes in the form of multiple conflicting estimates. The tornado description at the beginning of this section contains an example of two conflicting estimates of property damages.

Perhaps the most important principle in analyzing ambiguous data is to represent ambiguity in the summary statistics. A good example of this practice in the natural hazards loss analysis literature is Petak and Atkisson (1982 see especially Table 5-28, p. 245). They summarize expected loss estimates in ways that preserve both ambiguity and vagueness in those estimates, the former being due to two competing methods of loss estimation. Likewise, recently the Brisbane office of the Australian Meteorological Bureau (personal communication) has considered communicating ambiguous predictions of cyclone movements to the public. According to their data and best models, there are offshore regions in which cyclones either have a high probability of veering out to sea or a high probability of moving onto the coast. An analogous example (from Gardenfors and Sahlins 1982) is a tennis match in which we are told that one of the players is much better than the other, but we do not know which player is which.

Distortion often is considerably more difficult to represent, let alone quantify, than uncertainty. Nevertheless, some diagnostic and exploratory tools are available for at least gaining some insights into possible locations and sources of disinformation. Chief among the diagnostic indicators are lack of consensus from multiple sources on a single issue, lack of internal consistency (logical or otherwise) among different pieces of information, estimates or assessments that shift over time, and the presence of rhetoric or "hype" in information presentation.

Source credibility also is an important diagnostic aid. Indicators of credibility include the extent to which sources are differentially paid attention or sought after for information, believed, or trusted versus discounted or suspected. Perry and Lindell (1989) found that the two most frequent reasons given by citizens for naming a particular source as the "most credible" were "special skills/information" and "past reliability" (88% in one community study and 78% in another, with special skills/info. coming out on top). Lindell and Perry (1983) also suggest that expertise and trustworthiness are the two most important contributors to source credibility.

Finally, in situations where it is impossible to gauge the extent to which distortion may be operating, sensitivity analyses may be useful in gaining indications of how vulnerable decisions or assessments are to possible distortion in specific components of a system. These methods, while commonplace in engineering, only recently have begun to be applied to the study of unobservable social systems or events (e.g., Broesterhuizen's 1989 sensitivity analysis of the hidden economy).

Assessing Ignorance

Given appropriate representations of ignorance, it is reasonable to ask for ways of assessing its overall extent and distribution. Various measures of quantifiable uncertainty are available, again with probability being the most well-trodden domain in this regard. The dominant measure of probabilistic uncertainty is Shannon's (1948) information theoretic measure, often referred to as a measure of "entropy." An even earlier proposal, however, is Hartley's (1928), which also has been called an "entropy" measure. Hartley's measure actually indicates what Black would call ambiguity, or latitude of choice among alternatives. It has been generalized for use in possibility theory. Measures of fuzziness also have been proposed (see Smithson 1987 for a review), although debate over them is far from settled. Likewise, Smithson (1989b) has proposed a measure of relative freedom (or nonspecificity) in systems characterized by lower and upper bounds on proportions, percentages, or probabilities.

Equally important as the assessment of the extent of ignorance in a knowledge base is the analysis of its distribution. A distributional analysis can inform decisionmakers of which kinds of information are needed most, the major factors contributing to ignorance, and how much time or resources are required to obtain desired information. It can also clarify judgments concerning the tradeoffs involved in gathering more information versus taking action in the absence of that information. As Britton (1989, p. 17) observes, disaster management organizations are likely to lack vital information about such matters as when a disaster is going to occur, the location of impact, its intensity, scope, and eventual long-term effects on the impacted population. It is usually impossible for these organizations to obtain even best feasible estimates for all of these prognostications. Nevertheless, an explicit account of which among them is incompletely known and in what ways can aid decisions concerning which (if any) merit further investigation.

Representing and assessing ignorance also enables decisionmaking about the level of precision that is appropriate or affordable. Forecasting and responding to disasters are characterizable as, among other things, tasks in which precision is difficult and expensive. The British Meteorological Office recently was vexed by its inability to predict heavy flooding in some regions resulting from tidal surges. Among their difficulties is the relative lack of resolution in their computer models of oceanic currents (any phenomenon smaller than about 35km in diameter is indetectable, given the size of the model's grid). In the wake of the acquisition by the British Met Office of a Cray super computer (Bowler and Hamer 1990), discussions have focused on whether to reduce the entire offshore grid to 8km, or to reduce most of it to only 12 km, and reserve grids of 4 or even 1 km for "difficult locations" such as coastal areas with intricate currents. Likewise, longer-range forecasts would entail a less precise grid. Tradeoffs such as these become negotiable only when ignorance is explicitly represented and monitored.

FACTORS PROMOTING IGNORANCE BEFORE AND DURING DISASTERS

The Pre-Disaster Culture

Having discussed how and why to represent and analyze ignorance, let us now examine the factors that contribute to the production and maintenance of ignorance prior to disasters. Perhaps the most crucial insight here is that ignorance, far from being something that people invariably wish to avoid or reduce, often performs important psychological and social functions. Ignoring the prospect of disasters may be more comfortable for many people than having to face a realistic appraisal of their (lack of) preparedness for them. Being consciously ignorant about disasters and what to do about them may provide a convenient excuse for letting such matters rest in the hands of officials or experts.

Aside from obvious psychological functions such as denial or the maintenance of an illusion of control (Langer 1975), people may elect to ignore even available information because they are cognitively overloaded (Cohen 1978) or because other stimuli more effectively compete for their attention. As Simon (1978) has pointed out, in a world where attention is a scarce resource, much of what is offered in the name of information may be unaffordable. The sad fact is that information about disaster preparation or response must compete in the marketplace for public attention along with other information that may grab more attention simply by being more immediately interesting, understandable, relevant, entertaining, or exciting; and less depressing, daunting, or unnerving (Derber 1979). Any attempts to "educate" the public, let alone construct anything like a safety culture, which do not take these factors into account are likely to founder.

Clearly, certain conditions are likely to increase the likelihood that warnings, indicators of disaster onset or development, instructions for preparation, and other pre-disaster information will be ignored. Among these conditions are high stress, busyness, lack of time, the presence of conflicting messages about the disaster, feelings of helplessness, and beliefs that the disaster is irrelevant, improbable, or distant. In organizations, these conditions are mediated by structural factors such as organizational diversity and hierarchy. Generally, the greater the variety of people in an organization (i.e., diversity), the greater the organization's capacity to detect and process a wide variety of information (Weick 1987).

If we move to the level of social interaction, we find additional functional ignorance arrangements which may block communication or information dissemination. As Goffman (1959) argued, many kinds of ordinary social interaction require at least some privacy and/or secrecy arrangements. Mere information seeking may be inhibited or curtailed outright in domains characterized by taboos, secrecy, or fear (cf. Goody 1978). Reser and Smithson (1988), in their critique of dominant perspectives about public education and the threat of nuclear war, point to a contradiction in official policy which simultaneously "demands an educated, enlightened public while restricting access to crucial information in the name of national security" (p. 21). Clearly for some sectors of society, the maintenance of selective ignorance is not only considered beneficial; it is believed essential.

Contradictions such as these place risk or disaster communications in a severe bind. In a letter to the editor of *Risk Analysis*, Stallen and Coppock (1987) have articulated this dilemma by pointing out that on the one hand, we have recent policies in the West that favor open and full communication about risks. These seem to have been motivated by normative concerns and motivational arguments as well as public expectations that governments provide such information. On the other hand, several other concerns operate at cross-purposes to these motives for full communication. First, regulatory agencies worry about the aforementioned information "overload." Secondly, they do not wish to convey conflicting scientific assessments or prescriptions, because they want the public to receive a consensual and unambiguous messages about risks or disasters which they believe will engender unhesitating response to directives from authorities during a disaster.

Likewise, polite interaction (Brown and Levinson 1978) trades on vagueness, ambiguity, nonspecificity, and even distortion. Threatening information, for instance, is less likely to be transmitted than pleasant information. Several psychological studies (e.g., Tesser and Rosen 1975) have demonstrated a widely held aversion to conveying bad news to the person directly affected by it. Good news, on the other hand, tends to be communicated more frequently, quickly, fully, and more spontaneously.

News coverage of the AIDS epidemic in various countries is a good example of taboo-ridden information dissemination. The American media during the 1980s appeared to suffer from a "squeamish lack of specificity" (Alter 1985, p. 25) when it came to detailing how the virus is transmitted, hiding behind "polite euphemisms" (Burd 1989, p. 87). Burd also notes that American newspaper editorials, while calling for education of the public about AIDS and providing repeated messages about how it could not be transmitted, seldom explicitly stated how it actually can be transmitted.

Nor did they dwell on the specific behavioural changes, sexually or otherwise, which would be needed to protect oneself (aside from the belated discussion of condom usage beginning around 1985). Instead, there were calls for further education and research. In Queensland, Australia there were active censorship efforts which prohibited AIDS-related publications that did contain such material.

Norms and motivations favoring restrictions on knowledge and communication abound in organizations. Among the most well known are the conditions listed by Janis (1972) for incubating "groupthink." Likewise, organizations that are highly segmented and have deep, rigid hierarchical structures (cf. Douglas' "grid/group" variables) are also likely to erect knowledge differentials and communications barriers. There are even some indications that organizations may become meta-ignorant in the sense of ignoring or underrepresenting the extent of uncertainty (March and Feldman 1981). Downs (1967) claims that bureaucratic officials may cover up ignorance in order to avoid controversies or lengthy negotiations. Janis (1972) claims that one symptom of groupthink is the suppression of any accounts of how ignorant participants actually are. To this Linnerooth (1984) adds three political agendas that militate against regulatory agencies being honest about ignorance: (1) The desire to maintain apparent control in order to legitimate and bolster authority; (2) the need to justify policy decisions with persuasive and apparently certainty-producing analyses; and (3) a preference for narrow rather than comprehensive analyses.

Finally, social and political values may restrict reality-testing, especially under "normal" (pre-disaster) conditions. As a number of sociologists have eloquently put it (e.g., C.W. Mills 1959, or Berger and Luckmann 1967), we live in second-hand worlds in which most of what we think we know never gets tested or experienced first-hand. However, reality-testing is intrusive and instrumental, and so it tends to be highly circumscribed and reserved for high-status members of society with approved authority, qualifications, competence, and trustworthiness. Wildavsky (1985) pursues this issue to several interesting conclusions. He argues that Western society has become more risk-averse in recent years, and that there is an emerging view that nothing new should be tried unless it is certain that no damage will result (his phrase is "trial without error"). Without trial, there is no error and hence no prospect for learning. Instead, over-regulation results, which in turn makes innovation expensive and difficult.

Ignorance and Disaster Response

The conditions during a disaster and immediately thereafter can, to say the least, yield a large amount of ignorance in the short term. Nevertheless, there are some avoidable factors that may worsen our knowledge at crucial times, and a number of these have been observed by various writers in the study of disasters. Perhaps the most important among these are defensive communication barriers, the failure to allocate resources for systematic information-gathering or on-the-spot observation, premature and/or careless reportage, and lack of effective coordination among the organizations involved (cf. Britton 1989).

The potential importance of these factors is highlighted by the research that has been done on organizational decision making during and immediately after disasters. Quarantelli and Dynes (1977, p. 24) note that such decisions typically must be made very rapidly, often at lower levels in the organization than those usually delegated important decisional tasks. These decisions also understandably are made with less consultation, greater individual autonomy, and less accountability than obtains during normal conditions. Moreover, the very bureaucratic structures which help organizations maintain themselves during times of stability are hindrances during disasters.

Quarantelli (1985) maintains that much of the post-disaster negative psychological outcomes are not due to the disaster itself, but instead a result of poor management and inept decisions by bureaucracies trying to help during the immediate post-impact period. Drabek (1986) also documents severe problems in inter-organization communication and coordination. Britton's (1983) report on the bushfires in Tasmania, and the "Ash Wednesday" fires in south-east Australia (Britton 1986) assembles a number of examples involving lack of systematic information gathering, lack of communication within the State Emergency Services organization itself, lack of communication among relevant organizations, blockages of communications on political grounds, confusion over the appropriate roles of different organizations in responding to the bushfires, and a perceived reluctance of management figures to hear critical input from subordinates.

MANAGING IGNORANCE AND LEARNING FROM DISASTERS

This section attempts to derive some strategic guidelines for maximizing our ability to learn from disasters despite our ignorance about them. First, we must recognize some of the factors that may inhibit the capacity for post-disaster learning. As I have argued at length elsewhere (Smithson 1989a), modern approaches to managing and decision making under ignorance no longer are oriented towards banishing or eliminating ignorance. Most of the newer paradigms on uncertainty and related topics prescribe what I have called "second-order" strategies for coping with ignorance.

Central to these strategies is the honest, explicit reportage of ignorance as a precursor to analyzing it. Cover-ups, false precision, and other constructions of knowledge that fail to represent the varieties and areas of ignorance of which people are aware will inhibit post-disaster learning, simply because such practices encourage meta-ignorance (false certainty). Some of Elliott's (1989) guidelines for how the media should cover disasters address these issues. Among these are skepticism of information provided by official sources, attention to relevant contexts, admissions of uncertainty when accurate facts are unavailable or unverifiable, and avoidance of selective attention to spectacular or traumatic events at the expense of broader coverage.

These latter concerns point to another inhibiting effect on learning from disasters which arises when either media coverage, scientific research, or organizational imperatives are too narrowly focused. While a certain degree of focused attention is necessary for learning, it is often too easy to define matters as irrelevant when in fact they are pertinent but also happen to be threatening, discrediting, or merely not very attention-grabbing. Wilkins (1989) chides the media for a tendency to present versions of disasters that are devoid of historical, social, or cultural contexts, and which ignore prior conditions and long-term aftermaths, focusing instead on immediate events and culpability. Similar criticisms could well be made of disaster-relevant organizations.

An overly selective definition of relevance also may impede public understanding of risks and disaster preparedness by restricting public discussion of risks, hazards, or disasters to special occasions (i.e., the onset and/or aftermath of a disaster or accident). The result is that references to such matters by the media become signals to the public that risks have increased or a disaster is imminent. Mazur (1981) found that merely increasing the coverage of a safety issue by the media also increases public doubts and fears, regardless of what really is the case. Perhaps the key to this problem is that many people have been taught that reliability or safety means they can afford to ignore a hazard.

The most important choices concerning ignorance and the management of disasters, however, reside in certain dilemmas of control which I have tried to articulate elsewhere (Smithson 1989a, Ch. 7). It is beyond the scope of this paper to provide more than a brief overview of those dilemmas here. Policy analysts such as Collingridge (1980) and Wildavsky (1985), ecologists (e.g., Clark 1980), and social planning and control theorists (e.g., Sennett 1970 and Cohen 1985) have described dilemmas of planning and control which point to much the same implications for disaster management.

Roughly speaking, there are two kinds of strategies for managing under ignorance. The first kind, which ecologists call "anticipation," requires advanced, fixed planning for future contingencies. This approach emphasizes the elimination and/or banishment of ignorance in order to gain foreknowledge of (and preferably control over) all future possibilities. The second kind, which is termed "resilience," involves coping effectively with dangers as they arise and learning to "bounce back" from unanticipated difficulties. While this approach does not entail the elimination of ignorance, it does require a willingness to know when and where one is ignorant and how to deal innovatively with that. Indeed, without at least some uncertainty, there is no room to innovate, and therein lies the nub of the dilemmas to which the aforementioned writers refer.

Anticipation works well as long as the environment is "well-behaved," i.e., predictable. Moreover, its appeal in terms of security and forward planning is obvious. However, the apparent safety in anticipation is bought at a price. Anticipatory control requires elaborate regulatory mechanisms, laws, large-scale bureaucratic structures, and centralized authority. All of these make innovation, flexibility, or diversity difficult and expensive, and consequently decrease the capacity of the system to respond effectively to an unanticipated catastrophe. The very organizational and cultural factors that eliminate or banish ignorance during normal times inhibit not only resilience, but the capacity to learn from disasters afterwards. Likewise, the cost and effort required to obtain sufficient information for predicting low-probability, high consequence events are considered prohibitive under even mundane conditions, to say nothing of disaster conditions.

While the nature of this kind of dilemma may be fairly clear, its solution of course is not. Moreover, other factors may exacerbate the issue of whether anticipation or resilience (or some mixture of the two) should be the preferred method of coping with disasters. Ironically, according to analysts such as Wildavsky and Cohen, people tend to favor anticipation when risks are high and/or when they are defending something valuable. Disasters, of course, fulfill both criteria and yet are very unlikely to yield the kind of foreknowledge required for anticipation to be an entirely reasonable strategy. On the other hand, resilience requires a high level of public trust in the organizations and institutions who are helping them flex and cope; and in the current political climate such trust is in rather short supply. Furthermore, anticipatory planning may actually decrease public trust in the organizations or institutions involved. For example, corporations or governments which are seen to be planning for a large-scale technological disaster may find themselves accused by the public of hypocrisy if they also have promulgated public assurances of safety (e.g., Faupel and Bailey 1988, p. 145).

Nevertheless, the willingness to openly admit and record our ignorance goes some way towards leading us out of this dilemma, regardless of the strategies adopted in the first instance. Careful attention to ignorance enables organizations and individuals alike to assess the parameters of whatever mistakes they have made; becoming conscious of ignorance is a necessary precursor to learning anything. Likewise, under many circumstances, a frank admission of ignorance increases public trust, particularly when it is accompanied by an invitation for the public to participate in further information gathering and decision making.

REFERENCES

Alford, R.R. and E.L. Feige. 1989. "Information Distortion in Social Systems: the Underground Economy and Other Observer-Subject-Policymaker Feedbacks." Pp.57-80 in *The Underground Economies: Tax Evasion and Information Distortion*, edited by E.L. Feige. Cambridge: Cambridge University Press.

Alter, J. 1985. "Sins of Omission." *Newsweek* September 23:25.

Barron, F.H. 1987. "Influence of Missing Attributes on Selecting a Best Multiattributed Alternative." *Decision Sciences*, 8:194-214.

Behn, R.D. and J.W. Vaupel. 1982. *Quick Analysis for Busy Decision Makers*. New York: Basic Books.

Berger, P.L. and T. Luckmann. 1967. *The Social Construction of Reality*. New York: Doubleday.

Beyth-Marom, R. 1982. "How Probable is Probable? A Numerical Translation of Verbal Probability Expressions." *Journal of Forecasting*, 1:257-269.

Black, M. 1937. "Vagueness: An Exercise in Logical Analysis." *Philosophy of Science* 4:427-455.

Bowler, S. and M. Hamer. 1990. "Storm Warnings: Can Britain Meet the Challenge?" *New Scientist* March 17:10-11.

Britton, N.R. 1983. *Bushfires in Tasmania, February 1982: How the Disaster Relevant Organizations Responded*. Disaster Investigation Report #6. Townsville, Queensland, Australia: James Cook University Centre for Disaster Studies.

________. 1986. "An Appraisal of Australia's Disaster Management System Following the "Ash Wednesday" Bushfires in Victoria, 1982." *Australian Journal of Public Administration*, XLV(2) June:112-127.

________. 1989. *Anticipating the Unexpected: Is the Bureaucracy Able to Come to the Party*? Working Paper 1. Sydney, Australia: Disaster Management Studies Centre, Cumberland College of Health Sciences.

Broesterhuizen, G.A.A.M. 1989. "The Unrecorded Economy and the National Income Accounts in the Netherlands: A Sensitivity Analysis." Pp.159-174 in *The Underground Economies: Tax Evasion and Information Distortion*, edited by E.L. Feige. Cambridge: Cambridge University Press.

Brown, P. and S. Levinson. 1978. "Universals in Language Use: Politeness Phenomena." In *Questions and Politeness*, edited by E.N. Goody. London: Cambridge University Press.

Burd, G. 1989. "Preventive Journalism and AIDS Editorials: Dilemmas for Private and Public Health." Pp.85-114 in *Bad Tidings: Communication and Catastrophe*, edited by L.M. Walters, L. Wilkins, and T. Walters. Hillsdale, New Jersey: Lawrence Erlbaum.

Clark, W.C. 1980. "Witches, Floods, and Wonder Drugs: Historical Perspectives on Risk Management." In *Societal Risk Assessment: How Safe Is Safe Enough?* edited by R.C.Schwing and W.A. Albers, New York: Plenum.

Cohen, S. 1985. *Visions of Social Control*. Cambridge: Polity Press.

________. 1978. "Environmental Load and Allocation of Attention." Pp. 1-29 in *Advances in Experimental Psychology, Vol. 1*, edited by A. Baum, J.E. Singer, and S. Valins. Hillsdale, New Jersey: Lawrence Erlbaum.

Collingridge, D. 1980. *The Social Control of Technology*. Milton Keynes: Open University Press.

Covello, V.T., P.M. Sandman, and P. Slovic. 1989. "Risk Communication, Risk Statistics, and Risk Comparisons: A Manual for Plant Managers." Pp.297-358 in *Effective Risk Communication*, edited by V.T. Covello, D.B. McCallum, and M.T. Pavlova. New York: Plenum Press.

Derber, C. 1979. *The Pursuit of Attention*. Oxford: Oxford University Press.

Douglas, M. 1966. *Purity and Danger: An Analysis of Concepts of Pollution and Taboo*. London: Routledge and Kegan Paul.

Downs, A. 1967. *Inside Bureaucracy*. Boston, Massachusetts: Little, Brown and Co.

Drabek, T.E. 1986. *Human System Responses to Disaster: An Inventory of Sociological Findings*. New York: Springer-Verlag.

Dubois, D. and H. Prade. 1980. *Fuzzy Sets and Systems: Theory and Applications*. New York: Academic Press.

Dynes, R.R. 1988. "Cross-Cultural International Disaster Research: Sociology and Disaster." *International Journal of Mass Emergencies and Disaster* 6:101-129.

Einhorn, H.J. and R.M. Hogarth. 1985. "Ambiguity and Uncertainty in Probabilistic Inference." *Psychological Review*, 92:433-461.

Elliott, D. 1989. "Tales from the Darkside: Ethical Implications of Disaster Coverage." Pp.161-170 in *Bad Tidings: Communication and Catastrophe*, edited by L.M. Walters, L. Wilkins, and T. Walters. Hillsdale, New Jersey: Lawrence Erlbaum.

Ellsberg, D. 1961. "Risk, Ambiguity and the Savage Axioms." *Quarterly Journal of Economics*, 75:643-669.

Faupel, C.E. 1988. "Organizational Preparedness and Response to the West Memphis, Arkansas Tornado." *International Journal of Mass Emergencies and Disasters* 6:185-195.

Faupel, C.E. and C. Bailey. 1988. "Contingencies Affecting Emergency Preparedness for Hazardous Wastes." *International Journal of Mass Emergencies and Disasters* 6:131-154.

Feige, E.L. 1989. "The Meaning and Measurement of the Underground Economy." Pp.13-56 in *The Underground Economies: Tax Evasion and Information Distortion*, edited by E.L. Feige. Cambridge: Cambridge University Press.

Gardenfors, P. and Sahlins, N.E. 1982. "Unreliable Probabilities, Risk Taking, and Decision Making." *Synthese* 53:361-386.

Goffman, E. 1959. *Presentation of Self in Everyday Life*. Garden City, New York: Doubleday.

Good, I.J. 1962. "Subjective Probability as the Measure of a Nonmeasurable Set." In *Logic, Methodology, and Philosophy of Science*. Stanford: Stanford University Press.

Goody, E.N. (ed.). 1978. *Questions and Politeness*. London: Cambridge University Press.

Hartley, R.V.L. 1928. "Transmission of Information." *Bell System Technical Journal*, 7:535-563.

Hattis, D. 1989. "Scientific Uncertainties and How They Affect Risk Communication." Pp.117-126 in *Effective Risk Communication* edited by V.T. Covello, D.B. McCallum, and M.T. Pavlova. New York: Plenum Press.

Howell, W.C., and S.A. Burnett. 1978. "Uncertainty Measurement: A Cognitive Taxonomy." *Organizational Behavior and Human Performance*, 22:45-68.

Janis, I.L. 1972. *Victims of Groupthink*. Boston, Massachusetts: Houghton Mifflin.

Kahneman, D. and A. Tversky. 1982. "Variants of Uncertainty." *Cognition* 11:143-157.

Kalbfleisch, J.D., J.F. Lawless, and R.J. MacKay. 1982. "The Estimation of Small Probabilities and Risk Assessment." In *Technological Risk*, edited by N.C. Lind. Waterloo, Ontario: University of Waterloo Press.

Kalton, G. 1983. *Compensating for Missing Data*. Ann Arbor: Institute for Social Research, University of Michigan.

Langer, E.J. 1975. "The Illusion of Control." *Journal of Personality and Social Psychology* 32:311-328.

Levin, I.P., R.D. Johnson, P.J. Deldin, L.M. Carstens, L.J. Cressey and C.R. Davis. 1986. "Framing Effects in Decisions with Completely and Incompletely Described Alternatives." *Organizational Behavior and Human Decision Processes* 38:48-64.

Levin, I.P., R.D. Johnson, C.P. Russo and P.J. Deldin. 1985. "Framing Effects in Judgment Tasks with Varying Amounts of Information." *Organizational Behavior and Human Decision Processes* 36:362-377.

Lichtenstein, S. and J.R. Newman. 1967. "Empirical Scaling of Common Verbal Phrases Associated with Numberical Probabilities." *Psychonomic Sciences*, 9:563-564.

Lindell, M.K. and R.W. Perry. 1983. "Nuclear Power Plant Emergency Warning: How the Public would Respond." *Nuclear News* January 26:49-53.

Linnerooth, J. 1984. "The Political Processing of Uncertainty." *Acta Psychologica* 56:219-231.

Lowe, I. 1990. "The Mismatched Duo of Science and Statistics." *The Weekend Australian* March 31-April 1:24.

March, J.G. and M.S. Feldman. 1981. "Information in Organizations as Signals and Symbols." *Administrative Science Quarterly* 26:171-186.

Mazur, A. 1981. "Media Coverage and Public Opinion on Scientific Controversies." *Journal of Communication* 31:106-115.

Meyer, D. 1982. "Adapting to Environmental Jolts." *Administrative Science Quarterly* 27:515-537.

Mileti, D.S. 1987. "Sociological Methods and Disaster Research." Pp.57-70 in *Sociology of Disaster*, edited by R.R. Dynes, B. DeMarchi and C. Pelanda. Milano: Franco Angeli Libri.

Mills, C.W. 1959. *The Sociological Imagination*. New York: Oxford University Press.

Nagy, T.J. and L.J. Hoffman. 1981. "Exploratory Evaluation of the Accuracy of Linguistic Versus Numeric Risk Assessment of Computer Security." *Technical Report GWUIIST-81-07*. St Louis: George Washington University, Computer Security Research Group.

Nakao, M.A. and S. Axelrod. 1983. "Numbers are Better than Words." *American Journal of Medicine*, 74:1061-1065.

Pepper, S. and L.S. Prytulak. 1974. "Sometimes Frequently Means Seldom: Context Effects in the Interpretations of Quantitative Expressions." *Journal of Research in Personality* 8:95-101.

Perry, R.W. and M.K. Lindell. 1989. "Communicating Threat Information for Volcano Hazards." Pp.47-62 in *Bad Tidings: Communication and Catastrophe*, edited by L.M. Walters, L. Wilkins, and T. Walters. Hillsdale, New Jersey: Lawrence Erlbaum.

Petak, W.J. and A.A. Atkisson. 1982. *Natural Hazard Risk Assessment and Public Policy*. New York: Springer-Verlag.

Podesta, B. and R.S. Olson. 1988. "Science and the State in Latin America." Pp.296-312 in *Managing Disaster: Strategies and Policy Perspectives*, edited by L.K. Comfort. Durham, North Carolina: Duke University Press.

Quarantelli, E. 1985. *Organizational Behavior in Disasters and Implications for Disaster Planning*. DRD Report Series #18. Newark, Delaware: University of Delaware, Disaster Research Center.

________. 1987. "A Concluding Commentary." Pp.403-416 in *Sociology of Disaster*, edited by R.R. Dynes, B. De Marchi, and C. Pelanda. Milano: Franco Angeli Libri.

Quarantelli, E. and R.R. Dynes. 1977. "Response to Social Crisis and Disaster." *Annual Review of Sociology* 3:23-49.

Reser, J.P. and M. Smithson. 1988. "When Ignorance is Adaptive: Not Knowing about the Nuclear Threat." *Knowledge in Society* 1:7-27.

Sennett, R. 1970. *The Uses of Disorder*. New York: Vintage Books.

Shannon, C.E. 1948. "The Mathematical Theory of Communication." *Bell System Technical Journal* 27:379-423.

Simon, H. 1978. "Rationality as a Process and as a Product of Thought." *American Economic Review*, 68:1-16.

Smithson, M. 1987. *Fuzzy Set Analysis for Behavioral and Social Sciences*. New York: Springer Verlag.

________. 1988. "Possibility Theory, Fuzzy Logic, and Psychological Explanation." Pp. 1-50 in *Fuzzy Sets in Psychology*, edited by T. Zetenyi. Amsterdam: North-Holland.

________. 1989a. *Ignorance and Uncertainty: Emerging Paradigms*. New York: Springer Verlag.

________. 1989b. "Measures of Freedom Based on Possibility." *Mathematical Social Sciences* 18:81-98.

Stallen, P.J. and R. Coppock. 1987. "About Risk Communication and Risky Communication." *Risk Analysis*, 7:413-414.

Tesser, A. and S. Rosen. 1975. "The Reluctance to Transmit Bad News." In *Advanced in Experimental Social Psychology*, vol. 8, edited by L. Berkowitz. New York: Academic Press.

Turner, B.A. 1978. *Man-made Disasters*. London: Wykenham.

Tversky, A. and D. Kahneman. 1981. "The Framing of Decisions and the Rationality of Choice." *Science*, 221:453-458.

Wallsten, T.S. forthcoming. "The Costs and Benefits of Vague Information." In *Insights in Decision Making: A tribute to the Late Hillel Einhorn*, edited by R.M. Hogarth. Chicago, Illinois: University of Chicago Press.

Wallsten, T.S., D. Budescu, A. Rappoport, R. Zwick, and B. Forsyth. 1986. "Measuring the Vague Meanings of Probability Terms." *Journal of Experimental Psychology: General* 115:348-365.

Weick, K.E. 1987. "Organizational Culture as a Source of High Reliability." *California Management Review* 29:112-127.

Weinstein, D. and M.A. Weinstein. 1978. "The Sociology of Nonknowledge: A Paradigm." in *Research in the Sociology of Knowledge, Sciences, and Art*, Vol.1. New York: JAI Press.

Wildavsky, A. 1985. "Trial Without Error: Anticipation vs Resilience as Strategies for Risk Reduction." in *Regulatory Reform: New Vision or Old Curse*, edited by M. Maxey and R. Kuhn. New York: Praeger.

Wilkins, L. 1989. "Bhopal: The Politics of Mediated Risk." Pp. 21-34 in *Bad Tidings: Communication and Catastrophe*, edited by L.M. Walters, L. Wilkins, and T. Walters. Hillsdale, New Jersey: Lawrence Erlbaum.

Yates, J.F., C.M. Jagaginski, and M.D. Faber. 1978. "Evaluation of Partially Described Multiattribute Options." *Organizational Behavior and Human Performance*, 21:240-251.

Zadeh, L.A. 1965. "Fuzzy Sets." *Information and Control*, 8:338-353.

________. 1978. "Fuzzy Sets as a Basis for a Theory of Possibility." *Fuzzy Sets and Systems* 1:3-28.

Zimmer, A.C. 1983. "Verbal vs Numerical Processing of Subjective Probabilities." In *Decision Making Under Uncertainty*. Amsterdam: North-Holland.

________. 1984. "A Model for the Interpretation of Verbal Predictions." *International Journal of Man-Machine Studies*, 20:121-134.