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The Role of Context in the Communication of Uncertain Beliefs

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Most decisions require an evaluation of the likelihood of events on which outcomes depend. A common mode of judgment under uncertainty is the interpretation of statements of belief expressed by others. Most previous research on the communication of uncertainty has focused on the interpretation and use of quantitative versus qualitative expressions (e.g., "90% chance" vs. "extremely likely"); in addition, a handful of articles have addressed the effects of contextual base rates on the interpretation of expressed beliefs. In this article we argue that the social, informational, motivational, and discourse context in which beliefs are constructed and statements are formulated provides myriad additional cues that influence what is expressed by speakers and what is understood by listeners. We advance a framework for organizing the six sources of information on which listeners rely (in addition to the denotation of the speaker's words) when updating beliefs under uncertainty: (a) the listener's prior beliefs and assumptions about the world; (b) the listener's interpretation of the social and informational context in which the speaker's beliefs were formed; (c) the listener's evaluation of the speaker's credibility and judgmental tendencies; (d) the listener's interpretation of the social and motivational context in which the statement was made; (e) the listener's understanding of information conveyed directly and indirectly by the speaker; and (f) the listener's interpretation of the social and discourse context in which the statement was embedded. Throughout this article we cite relevant research from decision making and social psychology, as well as examples from the risk communication literature. We conclude with some comments on the transmission of uncertain beliefs in groups, followed by a general discussion.

Most decisions must be made without definite knowledge of their consequences. Decisions under uncertainty require an evaluation of not only the desirability of potential outcomes but also their likelihood of occurrence. For example, the decision whether to invest in the stock market, purchase a product, or go to court depends on an evaluation of the likelihood that the market will go up, the product will be reliable, or the court will decide in one's favor.

People sometimes rely on statistics, computation, and scientific inference in forming their beliefs under uncertainty (see, e.g., Morgan & Henrion, 1990; von Windterfeldt & Edwards, 1986). More often, people make intuitive assessments using mental shortcuts or "heuristics" (see Kahneman, Slovic, & Tversky, 1982). A common and less well-understood mode of judgment under uncertainty involves the interpretation of statements made by others. For example, a policy maker might base her judgment of the likelihood of dam failure on an engineer's statement that such a failure is "extremely unlikely." Judgments based on beliefs expressed by others are unique because communication is an inherently social process; the collaboration between speaker and addressee is a joint project in which shared systems of meaning are invoked (Clark, 1996).

A natural starting point for investigating how people communicate their uncertain beliefs is to examine the mapping of speakers' probabilistic beliefs (e.g., 70%) into natural language (e.g., "fairly likely"), and the mapping by listeners back into point probabilities (see, e.g., Budescu & Wallsten,

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1995).[1] Although this approach has been fruitful, we believe that it neglects important contextual information that affects how beliefs are expressed and interpreted. In particular, we assert that the social context in which statements of belief are embedded can have a profound impact on what is expressed and understood and that linguistic expressions convey far more information than their surface content suggests.

This article examines how people communicate their uncertain beliefs in natural contexts. We begin by framing the issues and briefly reviewing past research on the topic. We next delineate a broader array of contextual features that may affect what is expressed and what is understood, organized in a loose conceptual framework. In the process we amplify our conclusions with examples from the risk communication literature. Third, we discuss the transmission of beliefs in groups. We conclude with a brief discussion of some implications of our approach.

THE INTERPRETATION OF PROBABILITY

Interpretation of expressed belief strength is problematic, even if the speaker provides a numerical probability. For example, if a friend tells me, "I'd say there's a 60% chance that we can still get tickets for the concert," what does this mean? According to the cooperative principle introduced by Grice (1975), the meaning of a statement is bounded by particular conversational norms. For example, the maxim of relation requires that the statement be relevant to the aims of the exchange. In the case of communicating uncertainty, the addressee is generally interested in information he or she can use to predict future states of the world. The maxim of quality enjoins the speaker to relate the truth; however, with the exception of games of chance, a single "true" degree of belief seldom exists; in the preceding example, neither the availability nor unavailability of concert tickets validates or invalidates the "60% chance" claim. Rather, the uncertain expression should correspond to propensities in the world in such a way that is understandable to addressees, lest the speaker violate the maxim of manner, which requires him or her to avoid obscurity. Thus, people must learn to use language with an agreed interpretation if the expression is to convey its intended meaning. As Jeffrey (1968/1988) observes:

> Learning to use the language properly is in large part like learning such skills as riding bicycles and flying aeroplanes. One must train oneself to have the right sorts of responses to various sorts of experiences, where responses are degrees of belief in propositions. (p. 96)

What are the "right" sorts of responses? We can judge the quality of these statements by at least two standards. First, and most fundamentally, we expect subjective probabilities to predict the truth as often as they promise. A person is said to be "perfectly calibrated" if x% of the statements to which he or she assigns an x% probability are true of the world (see, e.g., Lichtenstein, Fischhoff, & Phillips, 1982; Liberman & Tversky, 1993). Second, we can judge subjective probabilities by their coherence (i.e., the degree to which they follow basic rules of internal consistency). For example, the conjunction rule states that the probability of a conjunction of events cannot exceed the probability of its constituents. Hence, a person would be inconsistent if he said, "I think there is a 1% chance that the dam will fail this year," but later asserted that "There is a 2% chance that there will be an earthquake this year that will cause the dam to fail" (see, e.g., Tversky & Kahneman, 1983). Obviously, a set of beliefs that are not coherent cannot be calibrated. Under many conditions, intuitive judgment under uncertainty has been shown to exhibit bias in both calibration and internal consistency (see Kahneman et al., 1982).[2]

PAST RESEARCH ON THE COMMUNICATION OF UNCERTAINTY

The research literature on the communication of uncertainty, though fairly voluminous, dwells on a relatively narrow range of phenomena (for reviews, see Budescu & Wallsten, 1995; Wallsten & Budescu, 1995; Clark, 1990). First, several studies have focused on the numerical interpretation of verbal expressions such as "likely" and "improbable" (see Mosteller & Youtz, 1990). One approach has been to scale the degree to which a particular expression represents probabilities on the 0–1 scale. These "membership functions" are typically derived by asking subjects to make a series of judgments of which of two probabilities, depicted as visual "spinners," better characterizes a given expression and to what degree. Such studies have shown that verbal expressions can be characterized by single-peaked or monotonic membership functions on the (0,1) interval that can be meaningfully scaled (Wallsten, Budescu, Rapport, Zwick, & Forsyth, 1986; Rapoport, Wallsten, & Cox, 1987; Jaffe-Katz, Budescu, & Wallsten, 1989), though listeners tend to scale the membership functions of qualitative expressions more broadly than do speakers (Fillenbaum, Wallsten, Cohen, & Cox, 1991). In general, speakers use a wide range of qualitative expressions to communicate their uncertainty (e.g., Zwick & Wallsten, 1989). When people are asked to assign numbers to qualitative

[1] Throughout this article we refer to the source of a communication as the *speaker* and the recipient as the *listener,* though most of the conclusions will apply more generally to situations in which the message is transmitted through alternative modalities such as written statements and to situations in which the recipient is not the intended target of the message. In a later section of this paper we discuss the effects of modality and conversational roles.

[2] We should note that listeners also evaluate predictions under uncertainty by their informativeness. For example, the statement, "Rain is likely tomorrow," is not as informative as the statement "Approximately one-fourth inch of rain is likely to fall between 2 and 4 p.m." This topic is beyond the scope of this article; for more on the trade-off between accuracy and informativeness, see Yaniv & Foster, 1995.

expressions, they exhibit much more between-subject variability than within-subject variability (Johnson & Huber, 1977; Budescu & Wallsten, 1985; Mullet & Rivet, 1991).

A second tradition in the uncertainty communication literature concerns the preference for quantitative versus qualitative expressions (e.g., "70% chance" vs. "fairly likely"). In general, speakers prefer to use qualitative expressions, whereas addressees prefer to receive quantitative information (Erev & Cohen, 1990; Brun & Teigen, 1988; Wallsten, Budescu, Zwick, & Kemp, 1993). One explanation advanced in the literature is that quantitative expressions are perceived by the speaker to be unnaturally precise, and the vagueness inherent in qualitative statements helps capture their second-order uncertainty (e.g., Wallsten & Budescu, 1990).

A third tradition in past research on the communication of uncertainty concerns the accuracy of qualitative versus numerical judgments and the efficiency of decisions rendered on the basis of such information. Qualitative expressions, when interpreted as the peak values of their respective membership functions, can be as accurate as numerical expressions in a Bayesian updating paradigm (Rapoport, Wallsten, Erev, & Cohen, 1990; Hamm, 1991) and a calibration paradigm (Wallsten, Budescu, & Zwick 1993). Decision efficiency is generally tested by asking a speaker to express a qualitative judgment about the likelihood of an event to an addressee who makes a betting decision based on this information. In these studies addressees typically earn approximately the same amount of money whether the expression is in qualitative versus quantitative form (Budescu & Wallsten, 1990; Erev & Cohen, 1990). However, this conclusion is qualified by the finding that probability looms larger in choice (relative to dollar payoffs) when expressed quantitatively rather than when expressed qualitatively (Gonzalez-Vallejo, Erev, & Wallsten, 1994).

Effects of Context on Interpretation of Verbal Expressions

Most of the preceding conclusions concern the relationship between qualitative expressions and numerical probabilities, independent of the context in which the expressions are embedded. Some recent work has exposed effects of context on the interpretation of qualitative expressions of uncertainty. In particular, listeners are influenced by the perceived base rate of the event in question. For example, Wallsten, Fillenbaum, and Cox (1986) found that the word *probable* was assigned a higher number when it referred to the chance of snow in the North Carolina mountains in December than when it referred to the chance of snow in the North Carolina mountains in October. Qualitative expressions associated with more severe outcomes (e.g., "likely" death vs. "likely" injury) tend to be assigned lower numbers (Weber & Hilton, 1990; Merz, Druzdzel, & Mazur, 1991; but see Sutherland et al., 1991, for a counterexample); this effect may be due to the fact that more severe outcomes tend to have lower base rates. Qualitative expressions associated with positive valenced outcomes tend to be assigned higher numbers than those associated with negatively valenced outcomes (Mullet & Rivet, 1991; Cohen & Wallsten, 1992). Finally, listeners appear to interpret qualitative expressions more regressively (i.e., closer to .5) than do speakers (Budescu & Wallsten, 1990; Fillenbaum et al., 1991). This conservatism might be explained by a Bayesian account in which listeners update a prior probability of .5.

Toward a Broader Consideration of Context

The literature reviewed thus far suggests that listeners base their interpretation of qualitative expressions not only on the specific language used, but also on their knowledge or prior beliefs regarding the event in question. In fact, we argue that listeners construct their beliefs about uncertainty based on a much broader array of contextual information than has previously been considered.

To motivate our approach, suppose that Jane says to John, "I think that rain is very likely tomorrow." John can ask himself three questions in response to this statement. First, he may be interested in what Jane *means* by her statement; that is, the strength of the belief she intends to express that it will rain (as well as other information that Jane intends to communicate). Second, John may be interested in what Jane truly *believes* when making this statement; that is, her sincere underlying degree of belief that it will rain and the basis of that judgment. Finally, John may want to estimate the *true propensity* of the target event; that is, how likely he is to get wet if he doesn't carry an umbrella. We have no reason to expect that the answers to these three questions will necessarily coincide: first, a speaker's beliefs do not necessarily correspond to the propensity of events in the world (e.g., Jane's belief that rain is likely may be predicated on information obtained from an out-of-date newspaper); second, speakers do not always intend to express what they truly believe (e.g., perhaps Jane believes that rain is only marginally likely but is afraid that John won't carry an umbrella unless she exaggerates this belief).

All three questions (speaker's meaning, speaker's underlying belief, event propensity) are interesting in their own right. However, our central concern in this article is to understand how natural language is used as a tool by speakers and listeners for updating listeners' beliefs about the propensity of target events, as is the central concern of those interested in (for example) risk communication. This being said, we assert that listeners may rely on many sources of data when updating their beliefs in light of statements made by others and that they may implicitly ask themselves all three questions.

The sources of information available to listeners can be organized around the process a speaker goes through in formulating his or her communication under uncertainty. Figure 1 illustrates a simple conceptual framework: The left-hand side depicts the formation and expression of the speaker's

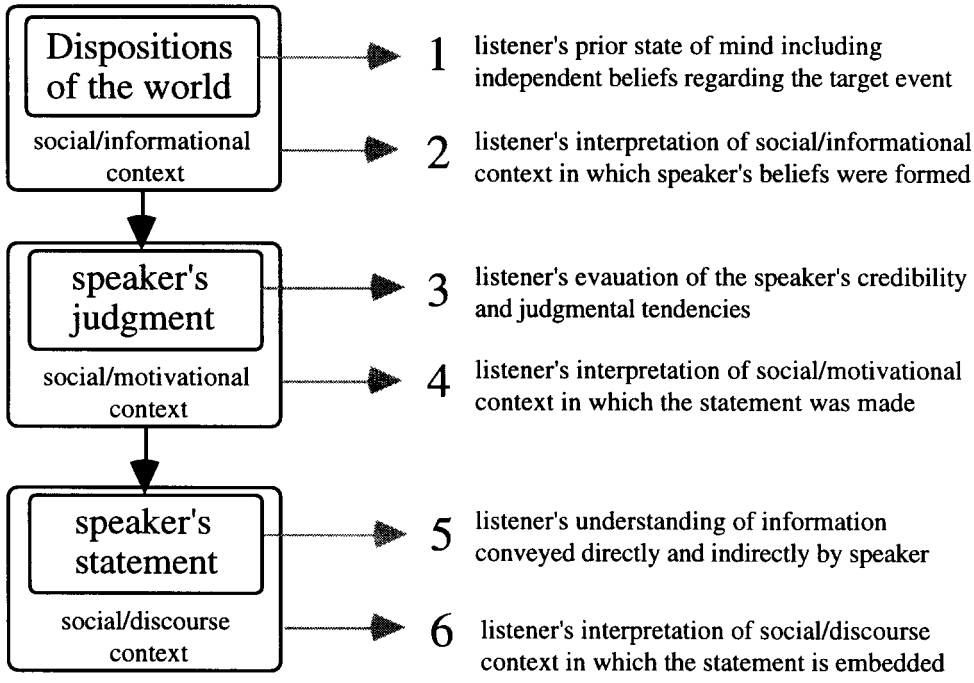

FIGURE 1 Six sources of information in the communication of uncertainty.

statements. The speaker observes dispositions of the world and forms a belief about the likelihood of the target event through some combination of computation, intuitive judgment, and/or information received from others. Having formed a belief, the speaker constructs a statement that is expressed to an addressee. Each of these processes are embedded in a particular context: the speaker's beliefs are constructed under some informational constraints, motivational state, and situational goals; the speaker chooses how to express his or her belief under some motivational state and situational goals; the statement itself is embedded within a longer discourse and a particular social setting.

The right-hand side of Figure 1 depicts the information available to the listener, who not only relies on the denotation of the words used by the speaker, but also may be influenced by:

1. His or her prior beliefs about the propensity of the target event and assumptions about the world.
2. His or her interpretation of the social and informational context in which beliefs were formed by the speaker.
3. An evaluation of the speaker's credibility and judgmental tendencies, such as his or her propensity for accuracy or bias.
4. The social context in which the statement was made, which may have provided a motivation for the speaker to exaggerate or mitigate.
5. Characteristics of the statement itself, which is expressed in a particular modality and linguistic mode.
6. The nature of the discourse or situation in which the communication is embedded.

We discuss each of these factors in detail in the next section of this article.

SOURCES OF INFORMATION IN THE COMMUNICATION OF UNCERTAINTY

1. Listener's Prior State of Mind

It should be clear from the discussion thus far that the listener's task is constructive and involves more than merely mapping words into numbers. To begin with, the listener's prior state of mind will affect his or her beliefs after receiving the speaker's message. First, the listener brings to the discourse prior beliefs about the likelihood of target and related events. Second, the listener may be more willing to update some beliefs than others. Third, the listener's worldview and experience may affect both his or her prior beliefs and willingness to update those beliefs in response to the speaker's message.

Independent assessment of event propensity. We have seen evidence that contextual base rates influence the numerical interpretation of qualitative expressions. For example, when a speaker suggests that snow is "probable" in the North Carolina mountains in October, the listener may assume that "probable" in this context is a relative term that is not as extreme as the word *probable* in the context of snow in December (Wallsten et al., 1986). In this case, the listener's independent assessment of the likelihood of an event influ-

ences his or her numerical interpretation of the speaker's belief strength. Of course, in addition to influencing the listener's interpretation of the speaker's meaning, this independent assessment serves as a (Bayesian) prior belief that is updated in response to the speaker's statement. Regardless of a listener's interpretation of what the speaker meant by the word "probable" in this context, his or her previous belief about whether snow would fall in December will surely influence his or her willingness to reserve a room that month at a North Carolina ski resort.[3]

Willingness to update. The weight that listeners afford their prior beliefs relative to new information received from the speaker will depend both on the perceived diagnosticity of new information relative to known information and on the extent to which listeners' values are fixed or "crystallized" (Schuman & Johnson, 1976). Expertise and experience can cause values (and, presumably, related beliefs) to become crystallized. Moreover, deeply held social and political values are typically resistant to disconfirming information (Lord, Ross, & Lepper, 1979). For instance, many citizens appear to have crystallized negative views of nuclear power; these views are consistently held across surveys and are not noticeably affected by communications that contradict these beliefs (Slovic, Flynn, & Layman, 1991; Flynn, Slovic, & Mertz, 1993).

Strong emotional associations, particularly negative associations, may affect willingness to update beliefs. Research suggests that negative information, such as a high frequency of cancer cases near power lines, exerts a greater impact on posterior beliefs than does positive information such as a low frequency of cancer cases (see Slovic, 1993). The mere mention of negative information can exacerbate risk estimates, even when the communicated information is of dubious diagnosticity. In one study, a pamphlet concerning power lines presented with the disclaimer, "there is so little evidence about these [hazardous] effects [of power lines] that, at this point such arguments are just speculation" nevertheless significantly increased concern regarding that hazard (MacGregor, Slovic, & Morgan, 1994). Similarly, researchers have suggested that negative health symptoms, such as headaches, can greatly increase a person's subjective probabilities for ambient risk and decrease trust in communications indicating the risk is not dangerous (MacGregor & Fleming, 1996). Thus, a citizen may experience a recurring headache, decide (in the absence of supporting evidence) that the headache is caused by a local landfill, and as a result be both concerned and untrusting when officials communicate a low risk for the landfill. Strong negative associations may influence beliefs through both affective and cognitive routes; perhaps because it is more distinctive and vivid, negative information may be more available to memory and therefore may be afforded more weight in judgment (Tversky & Kahneman, 1973).

On the other hand, positive experiences associated with a very real risk, such as fishing in polluted waterways, can diminish listeners' willingness to update their prior belief that the activity is safe; a recent study found that fishermen willingly fished standing next to strongly worded warning signs exhorting them not to do so (May & Burger, 1996). Many studies have found, in fact, that pleasant activities involving voluntary risks are often viewed as less dangerous than activities involving less pleasant, involuntary risks, and that these prior beliefs are resistant to change (Slovic, Fischhoff, & Lichtenstein, 1979).

Listener's worldview and experience. People maintain particular assumptions about the world, including notions of justice and fairness. Listeners are motivated to revise their beliefs to reconcile them with the need to believe in a "just world" (Lerner, 1970). For example, listeners may decrease their estimations of the probability of disease if the disease affects unwitting "innocent" victims. Listeners may also interpret communicated risk information in accordance with their notions of who may "deserve" to face such a risk. For example, information suggesting that an individual is at low risk may be revised upward if a listener believes that the individual in some way deserves the risk (Triplet, 1992; Irwin, Jones, & Mundo, 1996; Stockols & Schopler, 1973). Likewise, people may ignore or underweight information concerning their own susceptibility to risk due to a motivational bias against believing that they themselves may experience misfortune (Weinstein, 1989).

Previous life experience may shape both the listener's prior beliefs and his willingness to update those prior beliefs. For instance, white males rate a host of technological risks as less probable than do white females and nonwhites of both genders; white males also display more trust for scientists and policy makers responsible for managing the risks (Flynn, Slovic, & Mertz, 1994). Thus, compared to other groups, white males have lower prior assessments of the risk posed by technological hazards and are more willing to update these beliefs in response to statements made by public officials.

Dake (1992) suggests that people can be classified into five archetypical worldviews: hierarchists, individualists, egalitarians, fatalists, and hermits. Within these worldview classifications, people differ both in their concern and in their focus toward risks (Palmer, 1996). For example, whereas hierarchists (who are patriotic and believe in law and order) are more concerned about heart disease than about X-rays, egalitarians (who are driven by a desire for social equity) exhibit the opposite pattern of concern. Focus of attention differs by worldview, as well; for financial risks, hierarchists pay more

[3] Posterior beliefs can be influenced not only by preexisting beliefs regarding the conclusion in question (e.g., "a dam failure will occur within 10 years"), but also by beliefs in distinct but logically related premises (e.g., "a major earthquake will occur within 10 years," "a major earthquake will result in dam failure," etc.), through a process of logical inference. These relationships are characterized and empirically tested in research on "probabilogical models" (see, e.g., McGuire, 1960; Wyer & Goldberg, 1970; Wyer & Hartwick, 1980).

attention to the probability of benefit and egalitarians pay more attention to the probability of harm.

Worldview is determined in part by the listener's relative status or standing in society. For example, those with less economic power will probably not have the trust in government and the powers that be that white males did in Flynn et al.'s (1994) study. From a prescriptive standpoint, models of listeners' risk perception, and speaker–listener risk communication need to include both cultural and socioeconomic variables (Vaughan, 1995a, 1995b). For most communications concerning the uncertainty surrounding potential hazards, speakers are in a greater position of power than are listeners. Research suggests that the speakers will not only misjudge the level of concern of the listeners in these cases, but may also not realize what aspects of the risk are more important to listeners.

2. Social and Informational Context in Which Speaker's Beliefs Were Formed

Listeners may make a host of inferences regarding the conditions under which the speaker's judgment was rendered. In particular, the listener's impression of the accuracy and credibility of the speaker's statement may be affected by his or her impression of the information available to the speaker, the speaker's motivation, the speaker's degree of accountability, and the speaker's goals when forming his or her belief. To the extent that a listener is sensitive to these situational factors, the listener may adjust his or her interpretation of statements made by the speaker regarding the propensity of the event in question.

Speaker's sources of information. The sources of information on which a speaker relies will obviously affect the accuracy of his or her judgment. First, if the credibility or diagnosticity of the speaker's sources is dubious, the listener may afford the speaker's statements lower weight in updating prior beliefs. For example, consider a reporter's conclusion that the probability of the budget deficit's narrowing next quarter is "extremely likely." The listener's judgment of the true likelihood could be affected by whether the reporter's conclusion were based on government sources or on a nonpartisan think tank.

Even if the speaker's sources of evidence seem unbiased, the amount of evidence on which his or her conclusions are based should be relevant to a listener in deciding how to act. First, the greater the body of credible evidence, the more willing the listener should be to update prior beliefs. Second, decision theorists have observed that people prefer to act under conditions in which they have more information regarding the likelihood of events rather than less (see, e.g., Keynes, 1921; Knight, 1921; Ellsberg, 1961; Heath & Tversky, 1991).

Speaker's unconscious motivational biases. In some situations, the listener may believe that although the speaker is truthfully expressing his or her beliefs, the speaker has a motivation to deceive himself or herself in forming those beliefs. Cognitive dissonance theory (Festinger, 1957) asserts that if the speaker's actions are not matched to his or her beliefs, the speaker may distort those beliefs to match his or her behavior; for example, a person who manages a nuclear power plant may have an overly optimistic belief about the safety of nuclear power. In addition, people exhibit positive illusions (Taylor & Brown, 1988) such as overconfidence and a tendency to maintain flattering views of their own abilities and attributes relative to other people; for example, a contractor may have an unrealistically optimistic forecast that he or she will complete a construction project on time and under budget.

Social context and objectives. A speaker's judgment may be influenced by the social context in which it was rendered. First, the nature of the relationship between speaker and addressee may be important. For example, the accountability of the speaker to the addressee or a third party may mitigate some judgmental biases (e.g., base rate neglect) and exacerbate others (Tetlock, 1992). Second, the speaker's objectives will influence the way in which he or she processes information. For example, Zukier and Pepitone (1984) demonstrated that subjects provided with both base rates and case data are more sensitive to base rates when instructed to act like "scientists analyzing data," and are more sensitive to case data when instructed to act like "clinicians" (see also Schwarz, Strack, Hilton, & Naderer, 1991).

3. Evaluations of the Speaker's Credibility and Judgmental Tendencies

The weight that listeners afford the speaker's statement when updating their beliefs is undoubtedly affected by their appraisal of the speaker's credibility (cf. Hovland, Janis, & Kelley, 1953). In fact, studies have shown that subjects display greater agreement with beliefs and attitudes advanced in persuasive messages by people portrayed as higher in expertise, trustworthiness, status, and even likability or attractiveness (see Eagly & Chaiken, 1993). Of course these features of the speaker vary in their diagnosticity of the speaker's credibility. Research has shown that listeners who are less involved in the subject of the communication tend to process source features more superficially and weight salient "peripheral" cues such as attractiveness or likability more heavily, whereas listeners who are more involved in the subject of the communication tend to process source information more systematically and weight diagnostic "central" cues such as (truly relevant) expertise and trustworthiness more heavily (Petty & Caccioppo, 1986). Moreover, the effect of source credibility on posterior beliefs depends on listeners being aware of the identity of the source before receiving the message (Sternthal, Dholakia, & Leavitt, 1978) can diminish over time (Hovland & Weiss, 1951) and can be reversed if the listener is favorably

predisposed to the conclusion in question (Sternthal et al., 1978).

Listeners may have an opinion not only concerning the credibility of the speaker, but also concerning the speaker's susceptibility to judgmental biases. First, the listener may have experienced the speaker to be overly optimistic or pessimistic in the past. For example, suppose that in John's experience when Jane tells him she thinks there is a "90% chance" that a particular sports team will win, the team wins only slightly more than half the time. In this case, Jane's judgment may be diagnostic, but it is overconfident. Based on this experience, John might recalibrate (regressively) his expectations of event propensity on the basis of Jane's future statements.

4. Social and Motivational Context in Which the Statement Is Made

In addition to judging the diagnosticity and calibration of the speaker's beliefs, listeners judge the sincerity of the speaker in expressing these beliefs. In particular, listeners may be sensitive to situational factors that provide an incentive for misrepresentation of true beliefs or may be sensitive to the dispositional trustworthiness of the speaker.

Situational factors. The social context in which the speaker issues a statement may provide an incentive to exaggerate or mitigate his or her true underlying belief about the event in question. First, the speaker may have explicit incentives to manage the impression of the addressee. For example, an attorney who bills clients by the hour might be motivated to exaggerate the possibility of winning if the case goes to court; a doctor enrolled in a managed health care plan might experience pressure to order fewer costly tests, and therefore downplay the risk expressed to a patient regarding a particular disease.

Research using the "communication game" paradigm suggests that speakers sometimes distort their expressed attitude about a target person to suit addressees' attitudes toward that person; for example, to ingratiate themselves to addressees. Over time these distorted messages can influence speakers' own impressions of that person (Higgins, 1992). One might speculate that if a speaker believes that he or she is talking to an audience who strongly wants to have a picnic on Sunday, the speaker might exaggerate his or her true belief that it will not rain. Further research is needed to support this claim.

Listeners appear to be sensitive to the influence of the speakers' accountability on the messages they express. In one study, even accountability to a potentially biased source such as a corporation or government organization appeared to increase credence in the message because listeners tend to believe that accountability reduces amplification of the probability or severity of a risk (Frewer, Howard, Hedderley, & Shepherd, 1996). A friend of the listener, who is not accountable to an outside agency, may exaggerate risk information in his or her communications, for example, because exaggerated information is more sensational.

Disposition of the speaker. In addition to making attributions about the situational factors influencing statements made by the speaker, the listener may have preexisting impressions about the speaker's disposition to convey his or her beliefs honestly and reliably. These impressions can have a substantial impact on both the listener's estimate of the speaker's true belief and the listener's willingness to update prior beliefs on the basis of information provided by the speaker.

Trust is a particularly salient issue in the risk communication literature. In particular, public mistrust of government agencies has been found to bias people's interpretation of risk assessments that these agencies promulgate. For example, when Slovic (1993) showed subjects a list of statements about a large nuclear plant in their community, he found that negative statements (e.g., "plant neighbors' health is worse than average") undermined trust in the plant's safety (as measured by self-report ratings) but that positive statements (e.g. "plant neighbors' health is better than average") did not significantly affect trust in the safety of the plant. One interpretation of this result is that negative information seemed more credible whereas positive information was interpreted as propaganda. This may stem from the fact that the source of the risk communication was initially mistrusted. In this case mistrust may decrease the tendency for listeners to update their (pessimistic) prior beliefs.

5. Information Conveyed Directly and Indirectly by Speaker's Statement

The literature on the communication of uncertainty has focused primarily on the interpretation of verbal expressions that qualify the belief strength of the speaker. However, in natural contexts, much more information is conveyed in these statements. In particular, listeners may be sensitive to the modality of communication, expressions of second-order uncertainty, and the linguistic mode in which statements are embedded.

Modality of expression. Most studies of the communication of uncertainty have presented subjects with written expressions about uncertainty. Although people often read experts' forecasts in the newspaper or other documents (e.g., by fax or via the Internet) they often receive information in richer modalities. To begin with, if a statement is spoken (e.g., over the telephone or in person), information is carried in the speaker's prosody. For example, consider the statement: "I think it is *fairly likely* that the Forty-Niners will win their next football game." If the speaker stresses the word *fairly,* he or she conveys a stronger hedge in the forecast that may be

interpreted by the listener as a weaker belief strength, compared to if the word *likely* had been stressed. Moreover, if a statement is made in person, the speaker's body language may convey important information (Harper, Weins, & Matarazzo, 1978). For example, a statement made with a quizzical facial expression may be interpreted as a stronger hedge or lower confidence than a relaxed facial expression; a statement made while shrugging one's shoulders may be experienced in a similar way. Also, auditory and visual modalities carry information that listeners can use to evaluate the speaker's truthfulness (see Ekman, 1992).

Expression of second-order uncertainty. We have seen that the speaker's second-order uncertainty can affect the listener's willingness to update prior beliefs. As mentioned, listeners interpret qualitative statements more regressively than do speakers (Budescu & Wallsten, 1990; Fillenbaum et al., 1991). Several studies of ambiguity aversion have reported evidence consistent with the notion that people interpret numerical probabilities more regressively when they express a greater degree of second-order uncertainty (e.g., Kahn & Sarin, 1988; Hogarth & Einhorn, 1990), less consensus among experts (Kunreuther, Meszaros, Hogarth, & Spranca, 1995), or less confidence on the part of the speaker (Hogarth & Kunreuther, 1989).

Evidence from the risk communication literature suggests that a listener's mistrust is compounded when the speaker expresses a range of possible probabilities in an effort to quantify second-order uncertainty. For example, Viscusi, Magat, and Huber (1991) presented subjects with communications from the Environmental Protection Agency (EPA) on environmental health risks and demonstrated that ambiguous risk information from a government source has a negative affect on trust, thereby increasing risk estimates by subjects. Johnson and Slovic (1995) found similar results using communications, ostensibly from the EPA, about a contaminated water site. When second-order uncertainty was articulated by including an explicit range of possible probabilities, many respondents attributed more honesty but also less competence to the agency. In protocols, subjects indicated that they had assumed second-order uncertainty surrounded the estimate, even when this information was not provided, and that they were mistrustful when only a point estimate was provided. On the other hand, many subjects indicated that explicit mention of second-order uncertainty made them nervous about the EPA's ability to precisely calculate the risk estimate. This damned-either-way result seems to be driven by the aforementioned distrust of respondents for government agencies.

Linguistic mode of expression. Whether speakers qualify their degree of belief with numbers (e.g., "70% chance") or words (e.g., "good chance"), the specific language that speakers choose may cause listeners to make attributions about the speaker and inferences about the speaker's reasoning. In particular, Fox and Malle (1997) distinguish between expressions conveyed in the *internal mode* (e.g. "I am *fairly sure* that...," and "I am *reasonably confident* that...") that reflect a qualification of uncertainty in the speaker's judgment, and expressions conveyed in the *external mode* (e.g., "I think there is a *good chance* that...," "I think there is a *high probability* that...") that reflect an estimate of the propensity for an event in the world to obtain. These investigators provide evidence that listeners map internal mode statements made by experts into higher belief strength than corresponding external mode statements. For example, in one survey, subjects said they were more willing to bet on a team that a bookie was "60% sure" would win than a team that a second bookie said had a "60% chance" of winning. The data also suggest that statements expressed in the internal mode convey more certitude and willingness to take responsibility for judgment than do corresponding statements expressed in the external mode. In one vignette an economist said he was "70% sure" that exports would increase in the subsequent month while another economist said he thought there was a "70% chance" that exports would increase. If exports later increased (so that both economists were "right"), most subjects said that they would rather promote the economist who expressed himself in the internal ("sure") mode; if exports later decreased (so that both economists were "wrong") most subjects said that they would rather fire the economist who expressed himself in the internal ("sure") mode.

Linguistic mode of expression may also convey information about the reasoning or information employed by the speaker. In particular, Fox and Malle (1997) suggest that internal mode expressions tend to be associated with "singular" reasoning based on specific scenarios, case information, or a "feeling of knowing," whereas external mode expressions tend to be associated with the use of "distributional" reasoning based on general classes, base rates, or models of causal systems in the world. For example, in one vignette subjects were presented with a person who said he was "70% sure" that he would be married within three years and another who said he thought there was a "75% chance" that he would be married within three years. Most respondents said that the speaker who used the internal ("sure") mode was more likely to have a specific person in mind than the speaker who used the external ("chance") mode even though the latter expresses higher (numerical) belief strength. Such inferences about the reasoning used by a speaker can easily have a substantial impact on the listener's willingness to update prior beliefs.

6. Social and Discourse Context in Which Statement Is Embedded

The communication of uncertainty occurs in a particular communicative context, often as part of an ongoing discourse. Language use is a joint project in which people contribute to their common ground in an orderly way (Clark & Shaefer, 1989). First, the preexisting common ground between speaker

and listener may be crucial in determining what is said and what is understood. For example, speakers sometimes make relative statements that rely on common knowledge (e.g., "Hoover Dam is more likely to fail than is Powell Dam."). More notably, speakers may rely on shared systems of meaning of qualitative expressions. For example, weather forecasters have a standardized language for assigning words such as *likely* or *possible* to particular numerical probabilities (National Weather Service, cited in Wallsten & Budescu, 1995).

Problems can arise when interlocuters belong to different subcultures. For example, physicians and parents have been shown in one study to interpret verbal terms such as *good chance* and *small doubt* slightly differently (Brun & Teigen, 1988). A particularly striking example of such a miscommunication is relayed by Augustine (1995) in the context of Martin Marietta Corporation's $3-billion purchase of General Electric Aerospace in 1993:

> In a midnight meeting a few days before the sale was to take place, evidence suddenly appeared that the Justice Department might not approve pivotal elements of the transaction because of alleged antitrust concerns .... To the dozen or so lawyers, ... *high probability* meant considerably more than fifty-fifty, perhaps even a 70% chance of success. To the engineers [including Martin Marietta's top two executives], it meant more like 99% or better. Thus the leadership of each company suddenly found itself plunged into a predicament that it had considered extremely remote until that moment. (p. 151)

Common ground is extended over the course of a conversation in which utterances are judged against their context in the discourse (Clark, 1996). What came before in the discourse is therefore quite relevant to the interpretation of statements made under uncertainty. In fact, evidence suggests that shared systems of communication can evolve over the course of a single conversation. In one study in which subjects coordinated their actions through spoken language to solve a cooperative maze game, interlocutors developed transient conventions for describing locations to one another (Garrod & Anderson, 1987). Perhaps people engage in similar entrainment when communicating uncertain beliefs, particularly in environments where multiple forecasts are made with the opportunity for feedback and clarification.

To the extent that common ground between speaker and addressee is important in the communication of uncertainty, the role of the listener with respect to the discourse is extremely important. In particular, addressees have an advantage over bystanders, eavesdroppers, and other listeners in understanding the speaker's meaning (Schober & Clark, 1989). Addressees are afforded an advantage not only because of the common ground they share with speakers, but also because they have opportunities for clarification that may not be available to other listeners (Clark, 1996).

Finally, the context in which the conversation is initiated may affect the listener's belief about the motives of the speaker and as a result the beliefs they develop regarding target events. For example, a prediction made by an expert in response to a query might be given more credence than an unsolicited prediction. This distinction between solicited and unsolicited information is particularly important for communications about complex public risks. As Fischhoff (1995) points out, the public does not necessarily want or need to be informed about every risk and about every nuance of each risk analysis (which are inherently subjective and problematic; see Morgan & Henrion, 1990). In this case, conversational norms may contribute to this mistrust and alarm. According to one norm (Grice, 1975), we expect each communication to be relevant to the current conversation and, according to another, we expect each communication to be as informative as needed for current purposes. So when government agencies tell the public about risks, they imply that the risks are relevant to everyday affairs, and by providing such detail, they imply that the detail is important too. Both implications may contribute to an exaggerated perception of these risks by the public.

COMMUNICATING UNCERTAINTY IN GROUPS

Our discussion thus far has focused primarily on communications from one person (or set of people) to another. Of course, uncertain beliefs are also communicated in more complex dynamics such as groups. In many group settings, all group members can serve as both speaker and listener. Group discussion can exert influences on beliefs in several ways; we will not attempt a comprehensive review of the group discussion literature. However, a particularly relevant phenomenon, choice shifts, deserves mention. *Group choice shift* refers to the general finding that, after discussion, judgments tend to shift in the direction of the most popular judgment (Stoner, 1968; for a review, see Meyers, 1982). If most people in the discussion group favor a fairly risky alternative, then postdiscussion decision will "shift" toward the risky end of possible alternatives. This shift toward a risky extreme inspired the original term *risky shift,* although subsequent research has shown that shifts do not always follow this pattern and may instead be toward a less risky or even neutral position.

Note that choice shifts appear to be driven by exposure to and/or discussion of other viewpoints. Choice shifts can occur at the levels of both individual and group judgment. Individuals can exhibit shifts after discussion with others, even when no group consensus procedure was involved. In fact, some well-known choice shift studies (e.g., Burnstein & Vinokur, 1975) did not require group consensus at all; some sort of exposure to the positions and/or arguments of others was all that was needed. Also, choice shifts have been shown for tasks involving uncertainty and risk as well as tasks that do not. A particularly relevant finding for the communication of uncertainty is that a group consensus process can amplify individu-

als' tendencies to weight individuating information more heavily than base-rate information when making probability judgments (Argote, Seabright, & Dyer, 1986). This finding has two notable implications: (a) exposure to others' biases in probabilistic judgment may actually increase one's own bias, and (b) group judgments are not immune to probabilistic bias (group judgments may actually be less accurate than those of individuals).

Two general (and related) explanations have been offered for choice shifts. The first, persuasive arguments theory (Burnstein & Vinokur, 1973, 1975), posits that discussion reveals unique arguments for the most favored position. Some of these arguments, if they are new to these group members, persuade those group members who are further away from the favored position to move closer to this favored position. The second explanation centers not on the exchange of arguments (i.e., beliefs), but rather on the consensus processes necessary for achieving a group decision. Because group members share norms of how consensus should be achieved (e.g., majority rules, median rules), they will weight their individual judgments using these social decision schemes (Davis, 1973, 1996). If the distribution of judgments is skewed, the consensus norms can induce an apparent shift in judgments. For example, if the norm is for a more risky decision and the distribution is skewed so that most individual members favor the risky decision but few individual members favor extreme caution, then the group decision will probably be more risky than the mean of the individual members' positions. Because the distribution of individual judgments is often skewed, group shifts tend to be toward one extreme of the scale (i.e., tend to "polarize"). Group judgment shifts may or may not be accompanied by a shift in individual members' beliefs; often the average postgroup individual members' decision lies between the original individual decision and the group consensus decision.

These two explanations concentrate on different elements of the social context and the force that the context exerts on judgments: Persuasive arguments concentrate on the sharing and changing of beliefs, and social decision schemes concentrate on consensus norms for combining judgments. These explanations are not incompatible; social decision schemes are accomplished at least in part through the sharing of information. Furthermore, persuasive arguments assumes a shift toward some central tendency judgment, which is a standard element of most social decision schemes. For our purposes, these theories are interesting because they underscore the importance of the social context in the construction of discussed beliefs.

Furthermore, elements such as group cohesion appear to affect choice shifts. Thus, a group that discusses often and shares many beliefs will shift more than will a group that is more fragmented (Myers & Bishop, 1970; Ward & Reingen, 1990). Ward and Reingen (1990) tested this hypothesis by measuring sorority women's beliefs about the probability that a party would be a success. These beliefs showed strong polarization in the sorority subgroups who discussed often among themselves and who were cohesive in other ways (e.g., who shared the same values and interests), but did not show polarization in the subgroup that was not cohesive. Thus, a full account of social context effects on communication of uncertain beliefs must include the larger group relationships among the particular speakers and listeners.

We are all part of many naturally occurring groups; much communication of uncertain beliefs occurs within these groups. People are more likely to interact with others who share their beliefs and values. Thus, people's beliefs will most likely show some degree of polarization naturally as they interact with others. Meyers and Bishop (1970) presented an intriguing set of studies based on this hypothesis. They asked teenagers who were classified as high, medium, or low on a racial prejudice scale to discuss racial issues in groups of like-minded (i.e., similarly classified) peers. Discussion significantly increased the difference in race-related beliefs among the high- and low-prejudiced groups (i.e., high-level became more prejudiced and low-level became less).

DISCUSSION

Communication of uncertain beliefs is a challenging task, yet somehow people manage to convey such beliefs, often quite successfully. A narrow normative treatment of this process focuses on the transmission of the speaker's probabilistic beliefs to the addressee; this transmission is especially effective if the speaker's probabilistic beliefs are well-calibrated, clearly expressed, and adopted isomorphically by the listener. As we have seen, a richer descriptive account exposes several ways in which these assumptions might not be met in practice. In natural environments, the process is complicated by the social, informational, motivational, and discourse context, multiplied further by any group dynamics that may be present. Perhaps because of this enormous complexity most research has focused on the interpretation and use of quantitative versus qualitative expressions with only limited attention to context. In this sense, communication of uncertainty has been viewed primarily as an information processing task—a simple mapping from numbers to words and from words to numbers.

We suggest a broader framework for investigating the communication of uncertainty that incorporates natural context by considering the speaker's constraints and motives, as well as the listener's goals and sources of information. Rather than view the listener's task as mapping language into numbers, it may be more productive to view the listener's task as constructing a representation of the speaker's state of mind. The speaker attempts to persuade addressees to believe that an event will obtain with a particular propensity. The speaker may or may not be sincere in this communication—he or she may, for example, be motivated to exaggerate his or her belief strength and confidence in order to promote action by the addressee. Moreover, the speaker may not be accurate—he or

she may, for example, have a tendency to make very conservative predictions so that events almost always occur when he or she says "fairly likely." Even in cases where the speaker is sincere and generally accurate, the listener may seek to understand the basis of judgment so that he or she can evaluate its diagnosticity. We have seen some preliminary evidence that speakers who cooperate in this joint project sometimes telegraph their degree of second-order uncertainty by choosing qualitative over quantitative expressions, or they may signal their reasoning by choosing "internal" versus "external" mode expressions. One direction for future research would be to document in more detail the norms governing communication under uncertainty and identify conditions under which this process consistently goes awry.

Our current understanding of the finer details of this process is quite limited, and there do not yet exist cogent theoretical models of most of the phenomena described in this article, much less a unified theory of communication under uncertainty. The framework in Figure 1 is helpful both in organizing the existing literature and in making more salient the areas where further research is needed. Currently, quite a bit is known about what speakers mean when they use particular qualitative expressions, especially when these expressions are disembodied from their naturally occurring social, informational, and discourse context. Considerably less is known about specifically how this context affects communication of uncertainty and how this information is used by listeners. We have reviewed some of the literatures relevant to these topics, but we recognize that many unanswered questions remain, partially because research on uncertainty and risk communication has not yet devoted much attention to social processing of beliefs. Many policy researchers have begun to recognize the need for more research on issues such as trust and social influences in the communication of risk (Chess, Salamone, & Hance, 1995), and we encourage more psychological research on the topic.

Insights From the Risk Communication Literature

Some of the most important practical examples of communication under uncertainty involve events that are difficult for either speaker or addressee to evaluate dispassionately and that involve private motives in addition to the simple transfer of information. Combining the usual discrepancy in information between listener and speaker with high emotion and charged political implications can induce complex contextual effects. The risk communication literature, which concentrates on the communication of policy-relevant risks, has explored some of these contextual variables. Although this arena has not received the same attention that other areas of uncertainty communication have, the existing studies strongly suggest that larger issues such as the listener's worldview, political beliefs and trust in the speaker are particularly important factors, and that these variables can interact with the effects of more commonly studied variables such as wording and mode.

Practitioners' experience with the task of communicating the risk from landfills, waste sites, air pollution, and so on, has persuaded them that the communication of uncertainty in these contexts is much more of an ongoing exchange than a single transfer from a speaker to a listener. Kunreuther and Slovic (1996, p. 125) suggest that the communication of complex risk might be thought of as a game, "in which the rules must be socially negotiated within the context of specific decision problems." Part of the game is to negotiate what aspects of the problem are relevant and possibly even the way in which uncertainty is defined.

Even the most careful risk assessment is predicated on particular assumptions about how to model the event in question (Jamieson, 1996). The risk of a reactor meltdown, for example, might be expressed as 10^{8} per year. Clearly the agency promulgating such a figure is not basing it on millions of reactor years of experience! Such a number is conditioned on a particular model of how a catastrophe might occur. In cases where social and ideological conflict exists between the speaker and listener (as is often the case for policy makers versus the public), substantial disagreement may exist about these assumptions on which assessed risks are conditioned.

Generally, apart from the case of games of chance, a single "true" probability seldom exists. Even beliefs that are internally consistent and well-calibrated may be uninformative (e.g., a sports fan who predicts that every team has an "even chance" of winning each of its games). Ultimately, the goal of communication under uncertainty is to coordinate action. The real consequence of such communication is to affect the degree of hope or concern that listeners experience and guide their decisions whether to exploit opportunities or take protective action.

One particularly troubling aspect of the communication of risks is that often the speaker (e.g., a scientist working for the government) and listener (e.g., a taxpayer) neither understand nor trust each other. If the listener and the speaker differ greatly in terms of prior beliefs, social status, experience with the risk, and worldview, then the communication is unlikely to resemble the smooth transfer of probability information that might be expected by normative models of the communication of uncertainty. Furthermore, if a risk has been discussed at length among the listeners, as is often the case with politically charged risks such as power lines and landfills, then it is likely that polarization will have taken place, and also that the listeners will be less amenable to updating their beliefs.

We assume throughout most of this article that the listener has something to gain from the speaker, and that the act of communicating uncertain beliefs is a valuable tool in democratic policy making. The U. S. political system supports the communication of information about hazards and risks. Of course, the decision whether to use this information to update prior beliefs is left to the listener. Some research suggests,

however, that in some situations mistrust of the political establishment is so pronounced that risk communication is actually counterproductive—for example in the case of nuclear waste sites (Slovic, 1993).

Final Thoughts

We have argued that contextual factors play an important and largely unspoken role in the communication of uncertainty. We have documented several factors that may cause the listener to misinterpret the speaker's meaning, misinfer the speaker's underlying belief, and/or misjudge the propensity of the event in question. Of course, many natural contexts afford an opportunity for listeners to provide speakers with feedback so that they can clarify their meaning and articulate contextual factors of which they are consciously aware. Such communication can only benefit from a more explicit two-way exchange of information, from speaker to listener and back again, acknowledging that the listener offers something useful in the exchange, allowing shared systems of communication to evolve. In the case of risk communication, this strategy of making the speaker and listener "partners" in the enterprise (Fischhoff, 1995) may satisfy both the democratic imperative for communication and the pragmatic requirement for progress toward a viable (if not optimal) solution.

In this article we argued that researchers and practitioners interested in the communication of uncertain beliefs should consider a broader array of contextual information than previously explored in any single literature. We have provided a preliminary framework for organizing these sources of information and a catalog of ways in which social, informational, motivational, and discourse context might affect what is expressed by speakers and what is understood by listeners. The picture that emerges from this preliminary investigation is, of course, incomplete, and a more unified theoretical account of communication under uncertainty awaits future research.

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REFERENCES

Argote, L., Seabright, M. A., and Dyer, L. (1986). Individual versus group use of base-rate over individuating information. *Organizational Behavior and Human Decision Processes, 38,* 65–75.

Augustine, N. R. (1995, November–December). Managing the crisis you tried to prevent. *Harvard Business Review,* 147–158.

Brun, W., & Teigen, K. H. (1988). Verbal probabilities: Ambiguous, context-dependent, or both? *Organizational Behavior and Human Decision Processes, 41,* 390–404.

Budescu, D. V., & Wallsten, T. S. (1995). Processing linguistic probabilities: General principles and empirical evidence. In J. Busemeyer, D. L. Medin, & R. Hastie (Eds.), *Decision making from a cognitive perspective.* New York: Academic.

Budescu, D. V., & Wallsten, T. S. (1990). Dyadic decisions with verbal and numerical probabilities. *Organizational Behavior and Human Decision Processes, 46,* 240–263.

Budescu, D. V., & Wallsten, T. S. (1985). Consistency in interpretation of probabilistic phrases. *Organizational Behavior and Human Decision Processes, 36,* 391–405.

Bumstein, E., & Vinokur, A. (1975). What a person thinks upon learning he has chosen differently from others: Nice evidence for the persuasive-arguments explanation of choice shifts. *Journal of Experimental Social Psychology, 11,* 412–426.

Bumstein, E., & Vinokur, A. (1973). Testing two classes of theories about group-induced shifts in individual choice. *Journal of Experimental Social Psychology, 9,* 123–137.

Chess, C., Salomone, K. L., & Hance, B. J. (1995). Improving risk communication in government: Research priorities. *Risk Analysis, 15,* 127–135.

Clark, D. A. (1990). Verbal uncertainty expressions: A review of two decades of research. *Current Psychology: Research and Reviews, 9,* 203–235.

Clark, H. H. (1996). *Using language.* Cambridge, England: Cambridge University Press.

Clark, H. H., & Shaefer, E. F. (1989). Contributing to discourse. *Cognitive Science, 13,* 259–294.

Cohen, B. L., & Wallsten, T. S. (1992). The effect of constant outcome value on judgments and decision making given linguistic probabilities. *Journal of Behavioral Decision Making, 5,* 53–72.

Dake, K. (1992). Myths of nature: Culture and the social construction of risk. *Journal of Social Issues, 48,* 21–37.

Davis, J. H. (1996). *Group performance.* Reading, MA: Addison-Wesley.

Davis, J. H. (1973). Group decision and social interaction: A theory of social decision schemes. *Psychological Review, 80,* 97–125.

Eagly, A. H., & Chaiken, S. (1993). *The psychology of attitudes.* Fort Worth, TX: Harcourt Brace Jovanovich.

Ekman, P. (1992). *Telling lies: Clues to deceit in the marketplace, politics, and marriage.* New York: Norton.

Ellsberg, D. (1961). Risk, ambiguity, and the Savage axioms. *Quarterly Journal of Economics, 75,* 643–699.

Erev, I., & Cohen, B. L. (1990). Verbal versus numerical probabilities: Efficiency, biases, and the preference paradox. *Organizational Behavior and Human Decision Processes, 45,* 1–18.

Festinger, L. (1957). *A theory of cognitive dissonance.* Palo Alto, CA: Stanford University Press.

Fillenbaum, S., Wallsten, T. S., Cohen, B., & Cox, J. A. (1991). Some effects of vocabulary and communication task on the understanding and use of vague probability expressions. *American Journal of Psychology, 104,* 35–60.

Fischhoff, B. (1995). Risk perception and communication unplugged: Twenty years of process. *Risk Analysis, 15,* 137–145.

Flynn, J., Slovic, P., & Mertz, C. K. (1994). Gender, race, and the perception of environmental health risks. *Risk Analysis, 14,* 1101–1108.

Flynn, J., Slovic, P., & Mertz, C. K. (1993). Decidedly different: Expert and public views of risk from a radioactive waste repository. *Risk Analysis, 13,* 643–648.

Fox, C. R., & Malle, B. F. (1997). On the communication of uncertainty: Two modes of linguistic expression. Unpublished manuscript.

Frewer, L. J., Howard, C., Hedderley, D., & Shepherd, R. (1996). What determines trust in information about food-related risks? Underlying psychological constructs. *Risk Analysis, 16,* 473–485.

Garrod, S., & Anderson, A. (1987). Saying what you mean in dialogue: A study in conceptual and semantic co-ordination. *Cognition, 27,* 181–218.

Gonzalez-Vallejo, C. C., Erev, I., & Wallsten, T. S. (1994). Do decision quality and preference order depend on whether probabilities are verbal or numerical? *American Journal of Psychology, 107,* 157–172.

Grice, H. P. (1975). Logic and conversation. In P. Cole & J. L. Morgan (Eds.), *Syntax and semantics: Vol. 3. Speech acts* (pp. 95–113). New York: Academic.

Hamm, R. M. (1991). Selection of verbal probabilities: A solution for some problems of verbal probability expression. *Organizational Behavior and Human Decision Processes, 48,* 193–223.

Harper, R. G., Weins, A. N., & Matarazzo, J. D. (1978). *Nonverbal communications: The state of the art.* New York: Wiley.

Heath, C., & Tversky, A. (1991). Preference and belief: Ambiguity and competence in choice under uncertainty. *Journal of Risk and Uncertainty, 4,* 5–28.

Higgins, E. T. (1992). Achieving " shared reality" in the communication game: A social action that creates meaning. *Journal of Language and Social Psychology, 11,* 107–131.

Hogarth, R. M., & Einhorn, H. J. (1990). Venture theory: A model of decision weights. *Management Science, 36,* 780–803.

Hogarth, R. M., & Kunreuther, H. (1989). Risk, ambiguity, and insurance. *Journal of Risk and Uncertainty, 2,* 5–35.

Hovland, C. I., Janis, I. L., & Kelley, H. H. (1953). *Communication and persuasion.* New Haven, CT: Yale University Press.

Hovland, C. I., & Weiss, W. (1951). The influence of source credibility on communication effectiveness. *Public Opinion Quarterly, 15,* 635–650.

Irwin, J. R., Jones, L. E., & Mundo, D. (1996). Risk perception and victim perception: The judgment of HIV cases. *Journal of Behavioral Decision Making, 9,* 1–22.

Jaffe-Katz, A., Budescu, D. V., & Wallsten, T. S. (1989). Timed magnitude comparisons of numerical and nonnumerical expressions of uncertainty. *Memory and Cognition, 17,* 249–264.

Jamieson, D. (1996). Scientific uncertainty and the political process. *Annals of the American Academy of Political and Social Science, 545,* 35–43.

Jeffery, R. C. (1968/1988). Probable knowledge. In I. Lakatos (Ed.), *The problem of inductive logic.* Reprinted in P. Gardenfors & N. Sahlin (Eds.), *Decision, probability, and utility.* Cambridge, England: Cambridge University Press.

Johnson, E. M., & Huber, G. P. (1977). The technology of utility assessment. *IEEE Transactions on Systems, Man, and Cybernetics, SMC-7,* 311–325.

Johnson, B. B., & Slovic, P. (1995). Presenting uncertainty in health risk assessment: Initial studies of its effects on risk perception and trust. *Risk Analysis, 15,* 485–494.

Kahn, B. E., & Sarin, R. K. (1988). Modeling ambiguity in decision under uncertainty. *Journal of Consumer Research, 15,* 265–272.

Kahneman, D., Slovic, P., & Tversky, A. (1982). *Judgment under uncertainty: Heuristics and biases.* Cambridge, England: Cambridge University Press.

Keynes, J. M. (1921). *A treatise on probability.* London: Macmillan.

Knight, F. H. (1921). *Risk, uncertainty, and profit.* Boston: Houghton Mifflin.

Kunreuther, H., Meszaros, J., Hogarth, R. M., and Spranca, M. (1995). Ambiguity and underwriter decision processes. *Journal of Economic Behavior and Organization, 26,* 337–352.

Kunreuther, H., & Slovic, P. (1996). Science, values, and risk. *Annals of the American Academy of Political and Social Science, 545,* 116–125.

Lerner, M. J. (1970). The desire for justice and reactions to victims. In J. Macauley & L. Berkowitz (Eds.), *Altruism and helping behavior* (pp. 205–229). New York: Academic.

Liberman, V., & Tversky, A. (1993). On the evaluation of probability judgments: Calibration, resolution, and monotonicity. *Psychological Bulletin, 114,* 162–173.

Lichtenstein, S., Fischhoff, B., & Phillips, L. D. (1982). Calibration of probabilities: The state of the art to 1980. In D. Kahneman, P. Slovic, & A. Tversky (Eds.), *Judgment under uncertainty: Heuristics and biases.* Cambridge, England: Cambridge University Press.

Lord, C. G., Ross, L., & Lepper, M. R. (1979). Biased assimilation and attitude polarization: The effects of prior theories on subsequently considered evidence. *Journal of Personality and Social Psychology, 37,* 2098–2109.

MacGregor, D. G., and Fleming, R. (1996). Risk perception and symptom reporting. *Risk Analysis, 16,* 773–783.

MacGregor, D. G., Slovic, P., and Morgan, M. G. (1994). Perception of risks from electromagnetic fields: A psychometric evaluation of a risk–communication approach. *Risk Analysis, 14,* 815–828.

May, H., and Burger, J. (1996). Fishing in a polluted estuary: Fishing behavior, risk consumption, and potential risk. *Risk Analysis, 16,* 459–471.

McGuire, W. J. (1960). Cognitive consistency and attitude change. *Journal of Abnormal and Social Psychology, 60,* 345–353.

Merz, J. F., Druzdzel, M. J., & Mazur, D. J. (1991). Verbal expressions of probability in informed consent litigation. *Journal of Medical Decision Making, 11,* 273–281.

Meyers, D. G. (1982). Polarizing effects of social interaction. In H. Brandstatter, J. H. Davis, & G. Stocker-Kreichgauer (Eds.), *Group decision making* (pp. 125–161). London: Academic.

Meyers, D. G., & Bishop, G. D. (1970). Discussion effects and racial attitudes. *Science, 169,* 778–779.

Morgan, M. G., & Henrion, M. (1990). *Uncertainty: A Guide to dealing with uncertainty in quantitative risk and policy analysis.* Cambridge, England: Cambridge University Press.

Mosteller, F., & Youtz, C. (1990). Quantifying probabilistic expressions. *Statistical Science, 5,* 2–34.

Mullet, E., & Rivet, I. (1991). Comprehension of verbal probability expressions in children and adolescents. *Language and Communication, 11,* 217–225.

Palmer, C. G. S. (1996). Risk perception: An empirical study of the relationship between worldview and the risk construct. *Risk Analysis, 16,* 717–723.

Petty, R. E., & Caccioppo, J. T. (1986). *Communication and persuasion: Central and peripheral routes to attitude change.* New York: Springer-Verlag.

Rapoport, A., Wallsten, T. S., & Cox, J. A. (1987). Direct and indirect scaling of membership functions of probability phrases. *Mathematical Modeling, 9,* 397–417.

Rapoport, A., Wallsten, T. S., Erev, I., & Cohen, B. L. (1990). Revision of opinion with verbally and numerically expressed uncertainties. *Acta Psychologica, 74,* 61–79.

Schuman, H., & Johnson, M. P. (1976). Attitudes and behavior. *Annual Review of Sociology, 2,* 161–207.

Schwarz, N., Strack, F., Hilton, D., & Naderer, G. (1991). Base rates, representativeness, and the logic of conversation: The contextual relevance of "irrelevant" information. *Social Cognition, 9,* 67–84.

Schober, M. F., & Clark, H. H. (1989). Understanding by addressees and overhearers. *Cognitive Psychology, 21,* 211–232.

Slovic, P. (1993). Perceived risk, trust, and democracy. *Risk Analysis, 13,* 675–682.

Slovic, P., Fischhoff, B., and Lichtenstein, S. (1979). Rating the risks, *Environment, 21,* 14–39.

Slovic, P., Flynn, J., & Layman, M. (1991). Perceived risk, trust, and the politics of nuclear waste, *Science, 254,* 1603–1607.

Sternthal, B., Dholakia, R., & Leavitt, C. (1978). The persuasive effect of source credibility: Tests of cognitive response. *Journal of Consumer Research, 4,* 252–260.

Stokols, D., & Schopler, D. B. (1973). Reactions to victims under conditions of situational detachment: The effect of responsibility, severity, and expected future interaction. *Journal of Personality and Social Psychology, 25,* 199–209.

Stoner, J. A. F. (1968). Risky and cautious shifts in group decisions: The influence of widely held values. *Journal of Experimental Social Psychology, 4,* 442–459.

Sutherland, H. J., Lockwood, G. A., Tritchler, D. L., Sem, F., Brooks, L., & Till, J. E. (1991). Communicating probabilistic information to cancer patients: Is there "noise" on the line? *Social Science and Medicine, 32,* 725–731.

Taylor, S. E., & Brown, J. D. (1988). Illusion and well-being: A social psychological perspective on mental health. *Psychological Bulletin, 103,* 193–210.

Tetlock, P. E. (1992). The impact of accountability on judgment and choice: Toward a social contingency model. *Advances in Experimental Social Psychology, 24,* 331–376. New York: Academic.

Triplet, R. G. (1992). Discriminatory biases in the perception of illness: The application of availability and representativeness heuristics to the AIDS crisis. *Basic and Applied Social Psychology, 13,* 303–322.

Tversky, A., & Kahneman, D. (1983). Extensional versus intuitive reasoning: The conjunction fallacy in probability judgment. *Psychological Review, 95,* 371–384.

Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology, 5,* 207–232.

Vaughan, E. (1995a). The significance of socioeconomic and ethnic diversity for the risk communication process. *Risk Analysis, 15,* 169–179.

Vaughan, E. (1995b). The socioeconomic context of exposure and response to environmental risk. *Environment and Behavior, 4,* 454–489.

Viscusi, W. K., Magat, W. A., & Huber, J. (1991). Pricing environmental health risks: Survey assessments of risk–risk and risk–dollar trade-offs for chronic bronchitis. *Journal of Environmental Economics and Management, 21,* 32–51.

von Winterfeldt, D., & Edwards, W. (1986). *Decision analysis and behavioral research*. Cambridge, England: Cambridge University Press.

Wallsten, T. S., & Budescu, D. V. (1995). A review of human linguistic processing: General principles and empirical evidence. *The Knowledge Engineering Review, 10,* 43–62.

Wallsten, T. S., & Budescu, D. V. (1990). Quantifying probabilistic expressions: Comment. *Statistical Science, 5,* 23–26.

Wallsten, T. S., Budescu, D. V., Rapport, A., Zwick, R., & Forsyth, B. H. (1986). Measuring the vague meanings of probability terms. *Journal of Experimental Psychology: General, 115,* 348–365.

Wallsten, T. S., Budescu, D. V., & Zwick, R. (1993). Comparing the calibration and coherence of numerical and verbal probability judgments. *Management Science, 39,* 176–190.

Wallsten, T. S., Budescu, D. V., Zwick, R., & Kemp, S. M. (1993). Preference and reasons for communicating probabilistic information in numerical or verbal terms. *Bulletin of the Psychonomic Society, 31,* 135–138.

Wallsten, T. S., Fillenbaum, S., & Cox, J. A. (1986). Base rate effects on the interpretations of probability and frequency expressions. *Journal of Memory and Language, 25,* 571–587.

Ward, J. C., & Reingen, P. H. (1990). Sociocognitive analysis of group decision making among consumers. *Journal of Consumer Research, 17,* 245–262.

Weber, E. U., & Hilton, D. J. (1990). Contextual effects in the interpretation of probability words: Perceived base rate and severity of events. *Journal of Experimental Psychology: Human Perception and Performance, 16,* 781–789.

Weinstein, N. D. (1989). Optimistic biases about personal risks. *Science, 246,* 1232–1233.

Wyer, R. S., Jr., & Goldberg, L. (1970). A probabilistic analysis of the relationships among beliefs and attitudes. *Psychological Review, 77,* 100–120.

Wyer, R. S., Jr., & Hartwick, J. (1980). The role of information retrieval and conditional inference processes in belief formation and change. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 13, pp. 241–284). San Diego, CA: Academic.

Yaniv, I., & Foster, D. P. (1995). Graininess of judgment under uncertainty: An accuracy–informativeness trade-off. *Journal of Experimental Psychology: General, 124,* 424–432.

Zukier, H., & Pepitone, A. (1984). Social roles and strategies in prediction: Some determinants in the use of base-rate information. *Journal of Personality and Social Psychology, 47,* 349–360.

Zwick, R., & Wallsten, T. S. (1989). Combining stochastic and linguistic inexactness: Theory and experimental evaluation of four fuzzy probability models. *International Journal of Man and Machine Studies, 30,* 69–111.