Two Dimensions of Subjective Uncertainty: Clues From Natural Language

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We argue that people intuitively distinguish epistemic (knowable) uncertainty from aleatory (random) uncertainty and show that the relative salience of these dimensions is reflected in natural language use. We hypothesize that *confidence statements* (e.g., "I am fairly confident," "I am 90% sure," "I am reasonably certain") communicate a subjective assessment of primarily epistemic uncertainty, whereas *likelihood statements* (e.g., "I believe it is fairly likely," "I'd say there is a 90% chance," "I think there is a high probability") communicate a subjective assessment of primarily aleatory uncertainty. First, we show that speakers tend to use confidence statements to express epistemic uncertainty and they tend to use likelihood statements to express aleatory uncertainty; we observe this in a 2-year sample of *New York Times* articles (Study 1), and in participants' explicit choices of which statements more naturally express different uncertain events (Studies 2A and 2B). Second, we show that when speakers apply confidence versus likelihood statements to the same events, listeners infer different reasoning (Study 3): confidence statements suggest epistemic rationale (singular reasoning, feeling of knowing, internal control), whereas likelihood statements suggest aleatory rationale (distributional reasoning, relative frequency information, external control). Third, we show that confidence versus likelihood statements can differentially prompt epistemic versus aleatory thoughts, respectively, as observed when participants complete sentences that begin with confidence versus likelihood statements (Study 4) and when they quantify these statements based on feeling-of-knowing (epistemic) and frequency (aleatory) information (Study 5).

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Virtually all judgments and decisions entail uncertainty. Whether we are choosing an investment, setting a budget, forecasting the performance of a job applicant, or estimating the likelihood of rain, we usually do not know in advance precisely how things will turn out. In recent decades a voluminous literature has explored the psychology of judgment and decision making under uncertainty (for collections of papers see, e.g., Gilovich, Griffin, & Kahneman, 2002; Kahneman, Slovic, & Tversky, 1982; Kahneman & Tversky, 2000; Keren & Wu, 2015; Koehler & Harvey, 2004). In this literature, uncertainty typically has been treated as a unitary construct, whose degree can be assessed directly using judged probabilities or rating scales, or inferred from choices among uncertain prospects. Conclusions from these studies are usually assumed to generalize broadly across different domains. This seems surprising given the qualitatively distinct forms that uncertainty may take. For instance, consider the uncertainty evoked by the following two questions: (a) "Is the Amazon river longer than the Nile?" (b) "Will a fair coin land heads in at least one of two flips?" In the first case, uncertainty stems from gaps in one's knowledge about a fact that is either true or false, whereas in the second case uncertainty stems from inherently stochastic behavior of a physical device in the outside world. This distinction mirrors a long-standing divergence of formal probability theories into those that conceive of probability as (a) one's degree of confidence that an event will occur, or is true versus (b) the propensity for a random outcome to obtain (Hacking, 1975). Thus, today's dominant schools of probability consist of Bayesians, who treat probability as a measure of subjective degree of belief, and frequentists, who treat probability as long-run stable frequencies of classes of comparable events.

In this article, we assert that the historic bifurcation of the probability literature echoes ambivalent intuitions that most people

have about uncertainty. Indeed, over the past few decades, behavioral researchers have occasionally proposed conceptual frameworks that distinguish variants of subjective uncertainty (Dequech, 2004; Howell & Burnett, 1978; Kahneman & Tversky, 1982; Keren, 1991; Peterson & Pitz, 1988; Rowe, 1994; Smith, Benson, & Curley, 1991; Smithson, 1989; Teigen, 1994). Most notably, Kahneman and Tversky (1982) distinguished "internal" uncertainty that is attributed to our state of knowledge from "external" uncertainty that is attributed to the dispositions of causal systems in the outside world. They further distinguish external uncertainty that is "singular" (an assessment of the particular case at hand—for example, this restaurant will probably succeed because it has a great location and chef) versus "distributional" (an assessment of the relative frequency of a class of similar cases—for example, this restaurant will probably succeed because it is part of a franchise whose new openings nearly always succeed).

More recently, Fox and Ülkümen (2011) took stock of such efforts and advanced a novel framework involving two independent dimensions: epistemic (knowable) uncertainty; and aleatory (random) uncertainty (see Table 1). These terms are sometimes used by philosophers (e.g., Hacking, 1975) and by the risk assessment and reliability engineering communities (e.g., Ang & Tang, 2006; Oberkampf, Helton, Joslyn, Wojtkiewicz, & Ferson, 2004) to characterize different forms of ontological uncertainty, but the distinction has rarely been applied by psychologists to studies of subjective uncertainty. Fox and Ülkümen (2011) characterized pure epistemic uncertainty as entailing missing information or expertise concerning an event that is, in principle, knowable. It is represented in terms of a single case that is (or will be) true or false and is naturally measured by confidence in one's knowledge or in one's model of the causal system that determines an outcome. These authors characterized pure aleatory uncertainty, in contrast, as entailing an assessment of stochastic behavior that may be associated with a particular subjective probability but is otherwise unpredictable. Aleatory uncertainty is represented in relation to a class of possible outcomes, is focused on assessing an event's tendency to obtain, and is naturally measured by relative frequency. Thus, Fox and Ülkümen's aleatory category shares characteristics with Kahneman & Tversky's distributional form of external uncertainty, whereas their epistemic category shares some features of Kahneman and Tversky's internal uncertainty and singular form of external uncertainty. We therefore expect that in many contexts the epistemic–aleatory and internal–external variants will be correlated.

This said, we emphasize that the epistemic–aleatory distinction is logically independent from the internal–external distinction. Internal uncertainty is usually epistemic (e.g., the statement "I am 90% sure that the capital of Turkey is Ankara" may reflect a quantification of the degree of confidence in one's knowledge) but it may be aleatory (e.g., the statement "I think there is a 90% chance that I answered the question about Turkey's capital correctly" may reflect an appraisal of how often one tends to be correct when one feels this confident). Similarly, external uncertainty can be either epistemic (e.g., the statement "I am 80% sure that Aaron will finish the project on time" may express a degree of confidence in one's imagined scenario of Aaron completing the necessary steps in a timely manner) or it can be aleatory (e.g., the statement "I'd say there is an 80% chance that Aaron will finish

the project on time" may reflect an appraisal of how often Aaron tends to complete his projects in a timely manner).

Unlike most previous authors, Fox and Ülkümen view epistemic and aleatory forms of uncertainty as theoretically independent dimensions.[1] Thus, while the correct answer to a trivia question might be seen by most people as entailing pure epistemic uncertainty and the outcome of a game of chance might be seen by most people as entailing pure aleatory uncertainty, most events could be seen as entailing various mixtures of these forms.[2] For instance, predicting the outcome of a football game may be seen as partly knowable (e.g., based on the relative strength of the teams, how they match up, which team has home field advantage) and partly random (e.g., the relative performance of the teams will vary on different occasions due to weather conditions, mental state of key players, arbitrary choices made by coaches and players). Importantly, Fox and Ülkümen (2011) stress the subjective nature of the epistemic–aleatory distinction, so that different individuals may have different views about the extent to which a particular event entails epistemic and aleatory uncertainty, and a given individual may even shift his or her views from one occasion to the next (see Wallsten, Budescu, Erev, & Diederich, 1997, for a similar observation).

Language of Uncertainty

Fox and Ülkümen's framework, like most that preceded it, appealed to reader intuitions and relied on a review of prior empirical findings reported in the literature. In this article, we begin to assemble more direct empirical support for the notion that people intuitively distinguish epistemic (knowable) from aleatory (random) uncertainty and that these attributions can vary by situation, individual, and/or momentary state of mind. Our tool for exploring intuitive conceptions of epistemic and aleatory uncertainty is the language that people use to communicate their beliefs. Language used to express uncertainty is interesting in its own right because it can profoundly influence decisions. Whether a jury convicts a suspect may depend on the way an eyewitness phrases her level of confidence, whether a patient chooses to undergo an operation may depend on the language used by his doctor in describing the likelihood of a successful outcome, and how the market reacts to an earnings forecast may depend on how a financial analyst chooses to indicate her level of credence in the analysis. An established body of research on the language of uncertainty has primarily focused on the numerical interpretation of qualitative probabilistic expressions, such as "likely" and "probable" (e.g., Brun & Teigen, 1988; Mosteller & Youtz, 1990; Sutherland et al., 1991). Most of the papers in this literature relied on paradigms in which research participants were asked to map various linguistic expressions onto probabilities (Brun & Teigen, 1988; Budescu & Wallsten, 1985; Lichtenstein & Newman, 1967) or onto points in a distribution (Juanchich, Teigen, & Gourdon, 2013). Results of this work suggest that the interpretation of

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[1] It is worth noting that Kahneman and Tversky (1982) acknowledged that the categories of uncertainty that they distinguish are not meant to provide a mutually exclusive and exhaustive classification system, though this topic is not developed further in their essay.

[2] For more on the independence of the epistemic and aleatory dimensions, see Fox & Ülkümen (2011) and Tannenbaum, Fox & Ülkümen (in press).

Table 1

Distinguishing Epistemic and Aleatory Dimensions of Subjective Uncertainty

Distinguishing characterisitcs	Epistemic (knowable) uncertainty	Aleatory (random) uncertainty
Attribution of uncertainty	Inadequate knowledge/skill	Stochastic behavior
Representation	Single case	Class of possible events
Focus of prediction	Binary truth value	Tendency to occur
Probability interpretation	Confidence or causal propensity	Relative frequency
Hypothesized linguistic marker	Confidence statements	Likelihood statements

Note. Adapted from Fox & Ülkümen, 2011.

qualitative expressions can vary systematically with a number of variables including (a) base rate of the event (e.g., the probabilistic interpretation of a "likely" diagnosis varies depending on how common the disease is; Wallsten, Fillenbaum, & Cox, 1986), (b) the severity of associated consequences (e.g., the probabilistic interpretation of a "likely" diagnosis varies depending on how pernicious the disease is; Weber & Hilton, 1990), (c) characteristics of the speaker (e.g., perceived credibility, optimism/pessimism; Fox & Irwin, 1998), and (d) characteristics of the listener (e.g., physicians vs. parents of small children may interpret likelihood statements differently; Brun & Teigen, 1988). However, to date, there has been relatively little empirical investigation of the relationship between variants of uncertainty and linguistic expressions (but see Olson & Budescu, 1997; Løhre & Teigen, in press).

The central thesis of this article is that people intuitively distinguish epistemic and aleatory dimensions of uncertainty, and that this dual conception is reflected in their use of natural language. We hypothesize that some expressions that we call *confidence statements* (e.g., "I am fairly confident," "I am 90% sure," "I am reasonably certain") qualify or quantify one's assessment of epistemic (knowable) uncertainty, whereas other expressions that we call *likelihood statements* (e.g., "I believe it is fairly likely," "I'd say there is a 90% chance," "I think there is a high probability") qualify or quantify one's assessment of aleatory (random) uncertainty.

It is worth emphasizing that we confine most of our attention in this article to subjective expressions of uncertainty. Thus, we generally preface likelihood stems (e.g., "there is a 90% chance") with words such as "I believe," "I'd say," and "I think" so that we do not confound subjectivity/objectivity of statements with confidence/likelihood expressions. The subjectivity or objectivity of verbal expressions (e.g., "my probability" vs. "the probability" in Kahneman & Tversky, 1982, or "I am certain" vs. "it is certain" in Løhre & Teigen, in press; see also Fox & Ülkümen, in press) is a topic worthy of independent investigation.[3]

Events that are purely epistemic or purely aleatory in the minds of most decision makers seem to map intuitively onto confidence and likelihood statements, respectively. Thus, it appears much more natural to say, "I'm 75% sure the Amazon is longer than the Nile" than it is to say, "I think there is a 75% chance that the Amazon is longer than the Nile." Likewise, it appears much more natural to say that "I believe there is a 75% chance that a fair coin will land heads at least once in two flips" than it is to say, "I am 75% sure that a fair coin will land heads at least once in two flips." More commonly, events entail a mixture of these forms of uncertainty, the relative salience of which could vary from person to person or occasion to occasion. For instance, when forecasting the outcome of a particular basketball game, one may assess one's confidence in how well the teams involved match up against each other (epistemic uncertainty) and/or how often each team has recently prevailed in similar contests (aleatory uncertainty). In this article, we explore the question of whether the language chosen by a speaker reveals the dimension of uncertainty that is most salient to that speaker (e.g., "I'm 75% sure that Team A will win" may signal attention to the epistemic dimension and "I think there is a 75% chance that Team A will win" may signal attention to the aleatory dimension).[4]

In this article, we confine our attention to *likelihood* statements of the form "I think there is an X% {chance, likelihood, probability} that . . ." and *confidence* statements of the form "I'm X% {sure, confident, certain} that. . . ." In selecting these terms, we focused on common English statements expressing subjective uncertainty that can be quantified so that we can compare across statement types, holding degree of belief constant. We thus excluded expressions of quantities (e.g., few, many) and frequencies (e.g., rarely, frequently). Moreover, we did not include negative

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[3] It seems clear that first-person active expressions (e.g., "I am certain") indicate a subjective personal judgment, whereas third-person passive expressions (e.g., "It is certain") suggest an objective appraisal that may follow from a consensus or explicit algorithmic calculation. Kahneman and Tversky (1982) propose that subjective versus objective probability statements tend to (imperfectly) map onto internal versus external forms of uncertainty, respectively, and Løhre and Teigen (in press) provide some data supporting this hypothesis (see also Fox & Ülkümen, in press). It is important to note, however, that the subjective–objective distinction is logically independent from the internal–external distinctions. Whereas assessment of the degree of internal uncertainty is generally subjective (e.g., the statement "I am fairly certain that his name is James" may reflect a subjective appraisal of uncertainty that is attributed to the mind of the speaker), it may sometimes be objective (e.g., the statement "It is fairly certain that life exists on other planets" may reflect a consensus of belief among astrobiologists based on a public body of knowledge that is inherently limited). Meanwhile, external uncertainty may be evaluated in either a subjective manner (e.g., the statement "I am fairly certain it will rain tomorrow" may be based on the speaker's impression of how strongly the current signs point to rain) or an objective manner (e.g., the statement "It is fairly certain to rain tomorrow" may reflect a formal calculation obtained from a weather foresting algorithm). A similar case can be made for the logical independence of the subjective–objective and epistemic–aleatory distinctions.

[4] This said, we acknowledge the possibility that in some circumstances, one could simultaneously express both forms of uncertainty (e.g., "I am fairly certain that there is a high probability that Team A will win."). In this case, the likelihood expression ("there is a high probability") may express uncertainty conditional on the speaker's model of the world, and the confidence expression ("I am fairly certain") may express the speaker's level of confidence in the validity of the model.

expressions (e.g., uncertain, not likely, doubtful), which cannot be quantified naturally. An informal review of uncertainty expressions drawn from previous literature (Brun & Teigen, 1988; Budescu & Wallsten, 1985; Druzdzel, 1989), cross-checked against a web search of usage frequency, suggests that the terms we selected are among the most common subjective and quantifiable expressions of belief (see Supplementary Materials).

Language Both Reflects and Influences Conceptions of Uncertainty

Assuming a speaker's conception of relevant uncertainty influences his or her choice of linguistic expressions, the question remains whether the converse is also true; that is, whether the choice of linguistic expression can influence how a person conceives of relevant uncertainty. The correspondence between language and thought has been the subject of active research and vigorous debate across the fields of philosophy (Chapman, 2000), psychology (Gleitman & Papafragou, 2013; Gentner & Goldin-Meadow, 2003), and neuroscience (Monti, in press). At one extreme, some researchers assert that thinking is mediated by a language-independent symbolic system (Gelman & Gallistel, 2004), and language is but a means for expressing mental experiences (Locke, 1824). According to this view, linguistic data can be used to study underlying thought processes (Boas, 1966). At the other extreme, some researchers assert that language influences or determines the categories, representations, and cognitive structures **AQ: 2** available to thought (Whorf, 1956; Losonsky, 1999; see Gentner & Goldin-Meadow, 2003). According to this view, language can bias cognitive representations. In the present investigation, we exploit the established correspondence between language and thought without assuming a single or even dominant direction of causality.

In the empirical section that follows, we first assess whether speakers mark qualitatively distinct forms of uncertainty with systematically different vocabulary (Studies 1 and 2). We next examine whether listeners are attuned to this distinction when presented with confidence and likelihood expressions (Study 3). Finally, we examine whether language can influence accessibility of epistemic versus aleatory events (Study 4) and whether asking people to quantify confidence statements ("I am ___% sure") versus likelihood statements ("I think there is an ___% chance") leads to differential weighting of epistemic versus aleatory information (Study 5). In our general discussion, we take stock of our results, assess the theoretical, methodological, and practical implications of our work, discuss its generalization across languages, and outline some directions for future research.

Study 1: Confidence Versus Likelihood Statements Distinguish Variants of Uncertainty in the *New York Times*

Using archival data, Study 1 tests the hypothesis that different sets of verbal expressions are associated with distinct forms of uncertainty. We hypothesized that when speakers are communicating their beliefs about events that entail primarily epistemic (knowable) uncertainty they tend to use confidence statements (e.g., sure, confident, and certain) and when they are communicating their beliefs about events that contain primarily aleatory (random) uncertainty, they tend to use likelihood statements (e.g., chance, likely/likelihood, and probability). As an initial test, we

collected a large sample of naturally occurring written confidence and likelihood statements and explored whether their referent events differed in a manner consistent with our characterization of epistemic and aleatory uncertainty (outlined in Table 1). As mentioned, according to our framework uncertainty should be perceived as primarily epistemic to the extent that the target event appears potentially predictable, given enough information or expertise, and/or is viewed as singular. In contrast, uncertainty should be perceived as primarily aleatory to the extent that the target event appears to be determined by random factors and/or is viewed as a member of an equivalence class. Thus, we expected that speakers will tend to use confidence (likelihood) statements to express epistemic (aleatory) uncertainty when characteristics of the speaker, the situation, or the prediction suggest events that tend to be viewed as more knowable/singular (random/distributional).

Procedure

Using the Proquest database, we screened all articles that appeared in the *New York Times* during calendar years 2008 and 2009 and searched for terms that qualified or quantified the uncertainty of the speaker. We operationalized confidence statements as any expression that included the words *sure*, *confident*, or *certain*, and likelihood statements as those that included the words *chance*, *likely*, *likelihood*, or *probability*.

As mentioned before, we selected these particular terms because we focus on commonly used, subjective, and quantifiable expressions of uncertainty. In addition, we excluded statements concerning hypothetical events and statements that do not identify an explicit event (e.g., "Suppose there is a 90% probability"; "Many people are not confident consumers"). Thus, we selected statements that (a) contained a real rather than hypothetical statement of uncertainty, (b) were made by or ascribed to a sentient predictor rather than a machine or prediction algorithm, and (c) referred to an uncertain event that was mentioned in the sentence containing the target expression or in the surrounding sentences.

We determined in advance a set of candidate characteristics that we hypothesized could influence a speaker's ability to predict the outcome of the event, such as *perspective* (whether the statement is communicated from the first person, second person, or third person perspective), *relation* (when a speaker is communicating uncertainty expressed by another person, and if so, whether this person is a stranger or acquaintance, romantic partner or close relative), and *control* (whether the speaker has the ability to control or bring about the event). We also examined several characteristics of the prediction, such as *source* (whether the basis of prediction appears to be calculation or logic, trends or facts, or intuition, or if it is not specified at all), and characteristics of the event such as *timing* (whether the uncertainty is about a past, present, or future event), *subject* (whether the target of uncertainty is a sentient or nonsentient[5]), and *type* (if a target is sentient, whether the uncer- **Fn5** tainty in question is regarding their mental states or their behaviors). Finally, judges indicated a summary impression of *locus of uncertainty* (whether the locus of uncertainty appears to be inside or outside the speaker's mind). A complete list of characteristics

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[5] Note the target about whom the prediction is made should be distinguished from the source of the prediction, which, as stated above, was always sentient.

on which we coded statements, along with coding instructions, is reported in Supplementary Materials.

For each target statement, we extracted five sentences that occurred before the target statement and five sentences that occurred after the target statement to facilitate coding of variables that required an understanding of the context. Two hypothesis-blind judges agreed on 78% of their independent initial coding categories, and resolved their disagreements through discussion.

Results

Our search criteria described above returned a total of 965 statements; 361 of these were confidence statements, and 604 were likelihood statements. Although speakers more often qualified[6] rather than quantified their uncertainty, likelihood statements were much more often quantified (24% of the time) than were confidence statements (11%), $\chi^2(1) = 22.72$, $p < .001$, echoing experimental findings from Olson and Budescu (1997), which showed a stronger preference to quantify aleatory than epistemic forms of uncertainty. The distribution of confidence and likelihood statements across our major coding categories are displayed in Table 2. We assume that the choice of language is typically made after the uncertain event, the source, and the speaker have been determined. Thus, in the analysis that follows we will take contextual attributes of uncertain statements as independent variables and take the choice of language as a dependent variable.

Speaker's ability to predict outcomes. In general, a speaker should perceive the outcome of an uncertain event to be more knowable (and should therefore be more apt to use confidence statements), if the outcome is experienced by him/herself than if it is experienced by another person ("perspective" coding category). Consistent with this reasoning, statements were much more often expressed using confidence language when communicated from the first-person perspective (41% of these cases) than from the second- or third-person perspectives combined (27%), $\chi^2(1) = 17.16$, $p < .001$. An example of a confidence statement from the first-person perspective is "I'm pretty confident that we're going to reach an agreement relatively soon," and an example of a likelihood statement from the third-person perspective is "They suggest about a 5% chance that world temperatures will eventually rise by more than 10° C."

Second, when a speaker is communicating uncertainty experienced by another person with whom the speaker has a more intimate connection (i.e., a close relative or friend as opposed to a stranger), he or she should perceive the outcome of this event to be more knowable and therefore be more apt to use confidence statements. Of the 239 third-person statements, 217 were codeable for relation. Among these cases, speakers more frequently used confidence statements if the other person was a friend, romantic partner or close relative (67%) than when the other person was a stranger or an acquaintance (24%), $\chi^2(1) = 10.35$, $p < .005$, consistent with our prediction.

Finally, to the extent that a speaker perceives that s/he has control over an uncertain event, he or she should perceive its outcome to be more knowable and should therefore be more apt to use confidence statements. Our data support this prediction: Speakers more often used likelihood statements when they seemed to have no control over the event (69%) than when they appeared

to have some influence over the event (21%) or when it looked like they could bring about the event (27%), $\chi^2(2) = 98.84$, $p < .001$.

Basis of the prediction. We conjectured that when uncertainty is attributed to a stochastic process or is viewed in frequentistic terms (i.e., it is aleatory), then one will naturally assess its degree using calculations, logic, trends or facts, whereas when the source of uncertainty is gaps in one's knowledge or lack of total confidence in a unique scenario (i.e., it is epistemic) then one will naturally assess its degree in a more intuitive way that may be difficult to articulate. Accordingly, we found that speakers more often used a likelihood statement when the prediction was based on calculation or logic (94%), than when it was based on trends or facts (79%), or intuition or no specific source (51%), $\chi^2(2) = 88.70$, $p < .001$.

Characteristics of the event. Our theoretical framework suggests that epistemic events are treated as if they are in principle knowable, whereas aleatory events are treated as random so that they could turn out in different ways on similar occasions. One would expect perceived knowability to vary systematically with time perspective: Past and present events (and facts that were or are currently true) tend to be in principle knowable, and uncertainty about them can be attributed to gaps in one's knowledge or information. Future events that have not yet occurred (or facts that are not yet true), in contrast, typically have multiple possible realizations and may be treated as more random or unpredictable. Thus, we expected that future events would be perceived as more aleatory and thus marked by likelihood statements, whereas present and past events would be perceived as more epistemic and thus marked by confidence statements. Indeed, we found that speakers more often used likelihood statements when the prediction involved an event that would take place in the future (71%) than when it involved an event that was in the past (45%) or was then-current (46%), $\chi^2(2) = 56.08$, $p < .001$.

Second, we expected that when predicting thoughts and behavior of sentient beings (i.e., organisms that may act in a purposeful way), people will often try to assess their confidence in a prediction of thoughts, intentions, or preferences (i.e., engage in singular reasoning that would naturally be expressed with confidence statements), whereas when predicting behavior of nonsentient objects people will be more apt to assess the relative frequencies of possible outcomes (i.e., engage in distributional reasoning that would naturally be expressed with likelihood statements). Indeed, we found that confidence language was used more frequently in relation to sentient targets (42%) than nonsentient targets (29%), $\chi^2(1) = 15.53$, $p < .001$.

To explore this finding further, we coded events about sentient targets according to whether they appeared mental (e.g., uncertainty about a person's motivation for speaking) or behavioral (e.g., uncertainty about whether a person will speak). We expected that among sentient targets, mental events would more naturally lend themselves to singular prediction of intention (and therefore confidence statements) and behavioral events would more naturally lend themselves to distributional observation of relative fre-

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[6] Any linguistic stem that was not quantified was coded as being qualified. Thus, rare instances in which there was no number or qualifying adverb (e.g., "I think it is likely" or "I am confident") would be coded as a qualified rather than quantified statement.

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Table 2
Number of Confidence and Likelihood Expressions as a Function of Speaker, Prediction, and Event Characteristics (Study 1)

Coding variable	Variable level	Confidence (N)	Likelihood (N)	p Value
Speaker				
Perspective	First person	290	411	$p < .001$
	Second or third person	71	193	
Relation (if third person)	Stranger or acquaintance	50	155	$p < .005$
	Friend, romantic partner, or close relative	8	4	
Control	No control	262	574	$p < .001$
	Influence	70	19	
	Can bring about event	29	11	
Prediction				
Source	None/intuition	282	289	$p < .001$
	Trends/facts	77	284	
	Calculation/logic	2	31	
Event				
Timing	Past	71	58	$p < .001$
	Present	100	87	
	Future	190	459	
Subject	Sentient	266	370	$p < .001$
	Facts/things/processes/events	95	234	
Type (if sentient)	Mental event	54	24	$p < .001$
	Behavioral event	212	346	
Summary measure				
Locus of uncertainty	Internal	184	115	$p < .001$
	External	177	489	

quency or tendency (and therefore likelihood statements). Indeed, we found that speakers more often used confidence statements when predicting mental events of a sentient target (69%) than when predicting behavioral events of a sentient target (38%), $\chi^2(1) = 27.45$, $p < .001$.

Summary impressions. Finally, we asked coders to form a general impression of whether the "locus of uncertainty" seemed to reside primarily inside the speaker (and therefore reflect a "lack of knowledge or evidence") or outside the speaker (and therefore be "inherently random/probabilistic"). We expected that internal locus would be associated more strongly with confidence statements whereas external locus would be associated more strongly with likelihood statements. Confirming this prediction, uncertainty about events for which our coders attributed a primarily internal locus were mostly expressed using confidence statements (62%), whereas uncertainty about events for which our coders attributed a primarily external locus were mostly expressed using likelihood statements (73%), $\chi^2(1) = 107.73$, $p < .001$.

Validity of linguistic grouping. Thus far, we have assumed that our grouping of linguistic statements into confidence stems {sure, confident, certain} versus likelihood stems {chance, likely/ likelihood, probability} best captures a natural psychological distinction between these stems into two categories. We next examine the validity of this a priori assumption. To do so, we examined whether the collection of coded categories of events (perspective, time, etc.) predicted our theoretically assumed mapping of stems into two categories better than all other possible mappings of the six stems into two categories. This would show that our a priori grouping of statements captures a statistically robust (and therefore, one presumes, psychologically meaningful) distinction that discriminates epistemic from aleatory uncertainty. Six stems can

be allocated to two nonempty categories in $(2^6 - 2)/2 = 31$ distinct ways.[7] Using the coding variables shown in Table 2 as predictors, **Fn7** we estimated a logistic regression model for each of these 31 possible groupings and compared the model fits (as measured by the pseudo-R^2). Reassuringly, the grouping with the highest pseudo-R^2 turns out to be our a priori classification of confidence versus likelihood statements (see Supplementary Materials for an analysis of all possible groupings of terms).

Table 3 reports the average marginal effects from the best fitting **T3** (and hypothesized) grouping of stems for all independent variables from the logistic regression analysis discussed above.[8] All mar- **Fn8** ginal effects are in the predicted direction, consistent with the analysis of raw proportions displayed in Table 2. For instance, controlling for the effects of all other variables in the model, compared to a speaker having no control, a speaker being able to partly influence the outcome increases the probability of using a confidence stem by roughly 43 percentage points, whereas being able to bring about the event increases the probability of using a confidence stem by about 24 percentage points. This regression also suggests that control, source of uncertainty, and perceived locus of uncertainty were the strongest independent predictors of whether the speaker used confidence or likelihood statements to

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[7] Note that we divide by 2 because the category labels (0, 1) are arbitrary so that, for instance, assigning the six stems into categories 1,1,1,0,0,0 is equivalent to assigning them to categories 0,0,0,1,1,1, respectively.

[8] See Supplemental Materials for a more detailed treatment of effect sizes of all predictors from all studies, with comparisons between average marginal effects and dominance statistics (Azen & Budescu, 2003; Azen & Traxel, 2009; Budescu, 1993), which are in accordance in terms of the importance rankings they imply.

Table 3

Results of Logistic Regression Model Predicting Confidence Versus Likelihood Statements for Study 1

Coding variable	Average marginal effects	SE	Z	p Value
Control				
No control	0	(Base)	—	—
Influence	.434	.045	9.57	.000
Bring about	.243	.078	3.12	.002
Source				
None/intuition	0	(Base)	—	—
Trends, facts	−.228	.028	8.08	.000
Calculation, logic	−.321	.078	4.13	.000
Locus				
Internal	0	(Base)	—	—
External	−.288	.052	5.56	.000
Timing				
Future	0	(Base)	—	
Present	.040	.05	.79	.429
Past	.005	.054	.10	.923
Subject type				
Nonsentient	0	(Base)	—	—
Sentient and mental events	.168	.057	2.94	.003
Sentient and behavioral events	.051	.030	1.72	.085
Perspective relation				
First person	0	(Base)	—	—
Not first person and distant perspective	−.064	.034	1.90	.057
Not first person and close perspective	.187	.122	1.53	.125
Not first person and relation uncodeable	−.025	.065	.38	.702

Note. Overall fit of the logistic regression model is reflected by McFadden's pseudo-R^2 = .247.

qualify or quantify their uncertainty. Importantly, this regression analysis confirms both our a priori grouping of linguistic stems into confidence and likelihood categories and our predictions concerning the direction of their associations with the psychologically relevant properties of the speaker (e.g., perspective, relation, control), the prediction (source), the event (timing, subject, type), and the summary measure of locus of uncertainty.

Discussion

Results of this study provide strong evidence from a large sample of naturally occurring expressions of uncertainty that speakers use confidence statements (e.g., "90% sure") and likelihood statements (e.g., "90% chance") in systematically different ways that correspond to hypothesized properties of epistemic and aleatory uncertainty. While speakers more often express themselves using likelihood than confidence statements overall, they were relatively more apt to choose confidence statements when adopting a first-person perspective (e.g., "I am reasonably confident"), expressing some measure of control over the outcome, basing the prediction on intuition (or no identifiable source), speaking about events related to a sentient agent (especially mental events), speaking about events in the present or past (that may, in principle, be knowable), and when uncertainty appeared to be attributable to internal sources (i.e., lack of knowledge or information). Speakers were more apt to choose likelihood statements, in contrast, when they adopted a second or third person perspective (e.g., "They think it is fairly likely to occur"), appeared to have limited control over the outcome, based the prediction on calculation/logic or trends/facts, were speaking about the behavior of

nonsentient objects, were speaking about events that were in the future (and therefore not yet fully knowable), and when uncertainty appeared to be attributable to the external world.

In the studies that follow we focus our attention on numerical expressions of uncertainty (e.g., "90% chance" vs. "90% sure"), though most of our conclusions will apply with equal force to qualitative expressions (e.g., "good chance" vs. "fairly sure"). We do so because using quantitative judgment circumvents the interpretive ambiguity of qualitative expressions. Moreover, doing so allows direct comparisons between different uncertainty expressions that use the same numerical quantifiers (e.g., "80% sure" or "80% confident" vs. "80% chance" or "80% probability"), or else allows us to statistically control for differences in subjective probability.

Study 2A: Explicitly Choosing Between Confidence and Likelihood Statements

Using archival data, Study 1 established that confidence statements are strongly associated with epistemic uncertainty, and likelihood statements are strongly associated with aleatory uncertainty. One virtue of Study 1 is that it examined language use in a natural setting in which speakers (or writers) have discretion over the words with which they express their uncertainty. In Study 2, we examined whether people have explicit intuitions concerning which kind of language is more natural for expressing different kinds of uncertain events.

Specifically, we asked participants to rate target events using the Epistemic–Aleatory Rating Scale (EARS), a measure recently developed to operationalize perceptions of these two forms of

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uncertainty (Fox, Tannenbaum, Ülkümen, Walters, & Erner, 2016). This 10-item scale (see Supplementary Materials) prompts participants to rate their agreement with a set of statements (about a given event) that refer to properties of epistemic uncertainty (e.g., Event X "is in principle knowable in advance") and aleatory uncertainty (e.g., Event X "is something that has an element of randomness"). Participants made these ratings with respect to the uncertain Event X (without any reference to either confidence or likelihood statements), using 7-point scales (1 = *not at all*, 7 = *very much*). We hypothesized that respondents would indicate that confidence statements sound more natural than likelihood statements when expressing uncertainty about events that they perceive to be more epistemic and they would indicate that likelihood statements would sound more natural than confidence statements when expressing uncertainty about events that they perceive to be more aleatory.

Method

We recruited 154 undergraduate students from the University of Southern California (USC) to participate in the study in exchange for course credit. We presented each participant with 10 events, randomly selected from a pool of 20 that we designed to represent a broad range of uncertain events familiar to undergraduate students in Southern California (see Table 4 for a complete list of events used). Half of the events concerned one's own future behavior or outcomes (e.g., "I will earn at least a 3.0 GPA this semester"), and half concerned the external world (e.g., "Intelligent life exists on other planets"). For each event, we presented participants with both a confidence statement template using "sure" language (e.g., "I am ___ % sure that USC will play in the Rose Bowl next January 1") and a likelihood statement template using "chance" language (e.g., "I think there is a ___ % chance that USC will play in the Rose Bowl next January 1").[9] The statements appeared one above the other, with position of statement type (confidence vs. likelihood) counterbalanced across participants. We first asked participants to indicate which statement template sounded most natural to them. On the next screen, we presented participants with only the template they had selected and asked them to complete this template by entering a number between 0 and 100 that best reflected their belief strength concerning the target event. The order of presentation of these 10 events was randomized for each participant.

Participants also rated the 10 events on the EARS, without any confidence or likelihood language, for example, "whether USC will win more football games next year than it did this year." The order of presentation of the task described above versus the EARS was randomized for each participant. For most events, the epistemic and aleatory subscales exhibited a negative, nonsignificant correlation (a list of Cronbach's alpha statistics and correlations at the event level can be found in the Supplementary Materials).

Results

We received blank responses to 29 items, so that we ended up with a total of 1,511 item responses from 154 participants. Overall, participants were equally apt to choose a confidence statement (49.8%) as a likelihood statement (50.2%; $z = .16$, $p > .100$).

Interestingly, participants judged likelihood statements as more natural than confidence statements when they did not believe that events would obtain. Among events that people quantified with a number less than or equal to .5, most were matched with the likelihood statement (68%) rather than the confidence statement, while among events that people quantified with a number above .5, most were matched with the confidence statement (62%) rather than the likelihood statement (38%), $\chi^2(1) = 133.45$, $p < .001$ (see Table 5). Thus, when participants picked the confidence statement, the mean subjective probability assigned was 74.7%. When participants picked the likelihood statement, the mean subjective probability assigned was 53.2%, $t(1,525) = 14.06$, $p < .001$.

For each of the 10 events, and for each participant, we calculated the mean of four *epistemicness* items, and the mean of six *aleatoriness* items from the EARS. Though not central to the present analysis, we conjectured that self-events might be rated higher in epistemicness and lower in aleatoriness than world-events, as participants might have greater feelings of control and predictability—or at least be in a better position to form a singular model—concerning events that directly affect them. Indeed, the data support this prediction: World-events were rated higher than self-events in aleatory uncertainty ($M_{world} = 4.79$, $M_{self} = 4.20$), $t(1,511) = 7.81$, $p < .001$, while self-events were rated higher than world-events in epistemic uncertainty ($M_{world} = 4.11$, $M_{self} = 4.28$), $t(1,511) = 2.66$, $p = .008$. A list of mean epistemicness and aleatoriness ratings for each event is listed in Table 4.

To see which factors predict whether participants selected the confidence statement (% sure) or the likelihood statement (% chance) as more natural, we used a logistic regression model. We analyzed the data at the event level, with 10 data points corresponding to each participant's responses to 10 events. Our logit model included for each event the participant's score on the epistemicness subscale (average of six EARS items), the participant's score on the aleatoriness subscale (average of four EARS items), an indicator of event type (0 = world-events, 1 = self-events), and the participant's subjective probability. We clustered standard errors by participant. Again conforming to our prediction, higher epistemicness scores were associated with more frequent choice of confidence statements over likelihood statements ($B = .147$, $p < .01$), and higher aleatoriness scores were associated with less frequent choices of confidence statements over likelihood statements ($B = -.097$, $p < .05$), controlling for subjective probability and event type (self vs. world). Participants more often chose confidence statements for events they assigned higher subjective probability ($B = .016$, $p < .001$). Moreover, the coefficient for event type was positive and significant ($B = .872$, $p < .001$), indicating that participants more often chose confidence statements to express uncertainty about self-related events (and probability statements to express uncertainty about world-events). The average marginal effects were 2.9 and -2.1 for epistemic and aleatory variables, respectively. That is, if the rate of change was constant, then we would expect a 2.9-percentage-point increase in the choice of sure statements for every 1-unit increase in epistemicness ratings, and a 2.1-percentage-point reduction in choice of sure statements for every 1-unit increase in aleatoriness ratings.

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[9] We used "sure" and "chance" instantiations of confidence and likelihood statements, respectively, because these are by far the most common and natural versions to quantify. In the *New York Times* dataset from Study 1, we found that 71% of quantified confidence statements used a "sure" stem and 90% of quantified likelihood statements used a "chance" stem.

Table 4
Events Evaluated by Participants in Studies 2A and 2B and Mean Aleatoriness and Epistemicness Ratings in Study 2A

Events	EARS ratings from Study 2A	
	Aleatoriness	Epistemicness
Self-events		
I will go to a party this weekend.	4.34	4.37
I will earn at least a 3.0 GPA this semester.	3.88	4.30
I will go to bed before 1 a.m. tonight.	4.51	4.10
I will speak to my parents at some point in the next week.	3.32	4.41
I will attend my next high school reunion		
(I will attend my 10-year high school reunion).	4.12	4.05
I will get married by the time I am 30.	5.70	3.15
I will travel out of state this summer.	4.00	4.77
I will attend graduate school.	4.32	4.75
I will participate in this subject pool at least one more time later this semester		
(I will get at least a B– in BUAD 307 this semester).	2.85	5.10
I will go to the beach sometime in March.	4.94	3.90
World-events		
Republicans will control the House of Representatives following the 2014 election		
(President Obama will be reelected in 2012).	4.64	3.95
There will be a commercially available cure for AIDS by 2020.	4.38	3.98
Intelligent life exists on other planets.	4.18	3.88
USC will win more football games next year than they did this year		
(USC will play in the Rose Bowl next January 1).	5.06	3.74
A major earthquake (at least 6.0) will hit Los Angeles in the next 10 years		
(A major earthquake [at least 6.0] will hit Los Angeles in the next 5 years).	5.18	4.28
The high temperature in downtown Los Angeles will be at least 65° F next Tuesday		
(The high temperature in downtown Los Angeles will be at least 70° F next Tuesday).	4.86	5.17
The movie *Lincoln* will win the Academy Award for Best Picture		
(*Slumdog Millionaire* will win the Academy Award for Best Picture).	4.64	4.30
The U.S. unemployment rate will go down in the next month		
(The U.S. unemployment rate will go up in the next month).	4.75	4.63
Lindsay Lohan will go back into rehab sometime in the next 5 years		
(Britney Spears will go back into rehab sometime in the next 5 years).	4.89	3.52
The Lakers will win most of their games in March.	5.37	3.60

Note. EARS = Epistemic–Aleatory Rating Scale; GPA = grade point average; BUAD = Business Administration; USC = University of Southern California. Events in parentheses are the versions that were used in Study 2B, modified for changes in current events.

Study 2B: Individual Differences in Language Choice

Studies 1 and 2A established a robust association between the choice of confidence versus likelihood statements and perceptions of epistemic versus aleatory uncertainty, respectively. In Study 2B we examine whether individuals with different chronic attitudes concerning uncertainty might use language in systematically different ways. A natural candidate for this investigation is the Locus of Control Scale (LOC; Rotter, 1966), which measures individual differences in how people perceive their ability to control self-relevant outcomes (in our analysis we found it more intuitive to reverse-code LOC scores so that higher score indicated a greater sense of internal control, with participant scores in our sample ranging from 5 to 21). While

the feeling of internal control is not a necessary condition for epistemicness (and not explicitly measured by any EARS items), it may be a sufficient condition for a sense of knowability, which should increase perception of epistemicness and thus the tendency to choose confidence language. Thus, we hypothesized that individuals with more internal locus of control (i.e., higher scores) would have a greater tendency to choose confidence language, but only for self-events, for which they might plausibly perceive some measure of control over the outcome.

Method

We recruited a new sample of 40 undergraduate students from USC to participate in the study in exchange for course credit. We employed the same methodology as in Study 2A, with three exceptions. First, the set of 20 events included a few slightly different items due to differences in timing of the studies that dictated the use of different current events (see Table 4). Second, each participant was presented with all 20 items (in an individually randomized order) rather than a randomly selected subset. Third, participants completed the LOC scale instead of rating each event on the EARS, and all participants did so only after making naturalness choices and filling in subjective probabilities for all events.

Table 5
Stem Selection as a Function of Assigned Probability in Study 2A

Probability assigned	Stem picked	
	Confidence (*N*)	Likelihood (*N*)
Less than or equal to 50%	196	420
Greater than 50%	595	347

Results

Each of our 40 participants responded to 20 statements, resulting in a total of 800 items. We dropped responses to two items in which participants reported a subjective probability greater than 100%, yielding 798 total items. We summed responses to 23 (nondistractor) items on the LOC scale to calculate a total LOC score for each participant, such that higher scores indicate more internal locus of control ($\alpha = .71$).

As a summary measure of behavior, we first calculated the total number of times a participant chose confidence language (sure), separately for the sets of self-events and world-events. Confirming our hypothesis, when predicting self-related outcomes, participants with higher LOC (i.e., a greater sense of internal control) chose confidence statements more frequently, $r = .342$, $p < .05$. In contrast, when predicting outcomes related to the external world, LOC did not significantly relate to frequency of choosing confidence statements, $r = .202$, $p > .10$.

To explore which factors influence whether participants chose the confidence statement or the likelihood statement, we used a logistic regression model. We analyzed the data at the event level, with 20 data points corresponding to each participant's responses to 20 events. The logit model including participant LOC scores, an indicator of event type (0 = world-events, 1 = self-events), and subjective probability, as well as the interaction between event type and LOC. We clustered standard errors by participant. Replicating results from Study 2A, participants were more apt to choose confidence statements for events they assigned higher subjective probabilities ($B = .033$, $p < .001$). Also replicating our previous results, the coefficient for event type was positive and significant ($B = 3.511$, $p < .001$), indicating that participants more often chose confidence statements to express uncertainty related to themselves than uncertainty related to the world.

More to the point of the present study, and also as predicted, there was a significant interaction between LOC and event type, such that participants with more internal locus of control beliefs were more likely to choose confidence statements, but only for self-related events, not for world-events ($B = .170$, $p < .005$).[10] An analysis of the average marginal effects (see Figure 1) suggest that for the self-events, we would expect a 2.1-percentage-point increase in choice of sure statements for every 1-unit increase in internal LOC beliefs ($p < .05$). In contrast, for the world-events, we do not expect the choice of sure statements to vary significantly by LOC ($p > .10$).
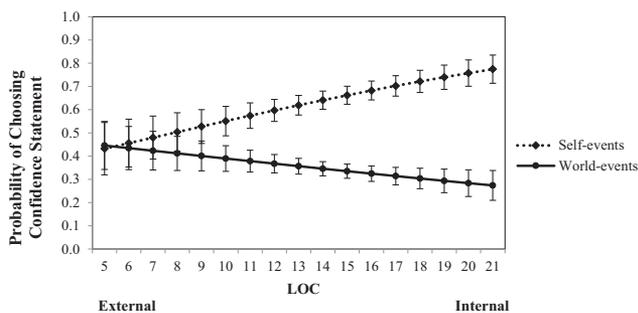

Figure 1.   Predicted probability of choosing a confidence statement as a function of locus of control (LOC) and event type in Study 2B. Error bars indicate standard errors.

Discussion

The results of Studies 2A and 2B suggest that speakers tend to favor confidence statements over likelihood statements when they perceive uncertainty concerning the target event to be more epistemic (and less aleatory; as measured using the EARS), and when they report general beliefs that life outcomes are more within their control (vs. outside of their control; as measured by the LOC scale). Together, these results illustrate that language used to express uncertain beliefs varies systematically with not only differences in perceptions of the inherent predictability of different events (as measured by the EARS) but also stable individual differences in perceptions of one's ability to control self-relevant events (as measured by LOC).

Study 3: Listener Inferences From Speaker Expressions of Uncertainty

The previous studies provide compelling evidence of an association between speakers' choice of confidence versus likelihood statements and their own perception of uncertainty as relatively epistemic versus aleatory. If this association exists in the minds of not only speakers but also listeners, then we should expect listeners to infer a particular form of uncertainty from the particular expression that a speaker has chosen. In Study 3, we test this notion by providing listeners with both confidence and likelihood statements expressing uncertainty concerning the same event and then asking them to match description(s) of the underlying reasoning or thinking to the uncertainty statement that fits best.

Method

We recruited a new sample of 128 undergraduate students at USC to participate in a study in exchange for course credit. Participants were presented with 10 pairs of statements. For each statement pair, one speaker communicated a probabilistic judgment about an event using a confidence (% sure) statement (e.g., "Colin says, 'I am 70% sure I'll win the poker tournament'"), and the other speaker communicated his or her judgment about the same event using a likelihood (% chance) statement with a matched probability (e.g., "Shane says, 'I think there is a 70% chance I'll win the poker tournament'"). Below these statements, participants were presented with one or two rationales (supporting thoughts) that the speaker might have relied on in making his or her statement (e.g., ". . . is thinking about his own poker skill"; ". . . is thinking about the poker skill of all players in the tournament"). Participants indicated which speaker was more likely to have relied on each rationale when formulating his or her statement.

We randomized the order of questions for each participant. Half the participants were presented with a confidence statement followed by a likelihood statement; half were presented with these statements in the reverse order. The order in which the possible rationales appeared

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[10] To rule out the possibility that our results were driven by the chance-related items in the LOC scale, we recalculated participants' scores on a redacted LOC scale, excluding six items related to the concepts of chance and luck (Items 2, 11, 13, 15, 16, 18). Thus, we retained items that tapped into concepts of control, fairness, and fate that were semantically unrelated to words like "chance" or "sure." Our results remain qualitatively the same with this redacted LOC scale.

was also counterbalanced when two were presented. On some trials, we asked participants to match two possible rationales to two possible uncertainty statements (with no enforced restriction that respondents match the two rationales to different statements); we did this to emphasize the contrast between two forms of reasoning. On other trials, we asked participants to match a single rationale with one of two possible uncertainty statements; we did this as a more conservative test that does not allow for matching reasoning based on elimination. A full list of uncertainty statements and rationales are presented in Table 6. We designed some rationales to express singular reasoning, a feeling of knowing, or internal control; we predicted that these would tend to be matched with confidence statements. We designed other rationales to express distributional reasoning, relative frequency information, or external control; we predicted that these

would tend to be matched with likelihood statements. Naturally, the aptness of the labels listed in Table 6 (in parentheses) is open to debate.

Results

In Table 6 we report the results for the large subsample of participants who, when presented with two rationales, always matched them to distinct uncertainty statements ($n = 105$). We note that the qualitative pattern of results remains identical if one examines the full sample of participants including those who sometimes match different rationales to the same uncertainty statement ($N = 128$). Results for all 10 trials accord with our predictions. For instance, most participants paired the confidence state-

Table 6

Statements and Rationales Used in Study 3

Item number	Statements and rationales[a]	Proportion of hypothesis consistent responses[b]
Question 1	Doctor Ames says, "I am 80% sure that you have Crohn's disease." *"This patient has most of the signs and symptoms of Crohn's disease." (singular reasoning)* Doctor Baker says, "I think there is an 80% chance that you have Crohn's disease." *"Most of the patients I have seen with these signs and symptoms have Crohn's disease." (distributional reasoning)*	62%
Question 2	Dick says, "I am 70% sure that the Celtics will beat the Knicks tonight." *"The Celtics have a stronger lineup of players than the Knicks." (singular reasoning)* George says, "I think there is a 70% chance the Celtics will beat the Knicks tonight." *"The Celtics have a better win–loss record than the Knicks." (distributional reasoning)*	75%
Question 3	Cade says, "I am 80% sure that I will be married within 3 years." *has a specific person in mind to marry (singular reasoning)* Peter says, "I think there is an 80% chance that I will be married within 3 years."	88%
Question 4	Ellen says, "I am 60% sure I will go to the beach this month." Sarah says, "I think there is a 60% chance I will go to the beach this month." *is thinking about how often she tends to go the beach in a typical month (distributional reasoning)*	66%
Question 5	Derek says, "I am 90% sure that Chip wore a vest sometime last week." *saw Chip last week (feeling of knowing)* Lyle says, "I think there is a 90% chance that Chip wore a vest sometime last week." *is thinking about how often Chip tends to wear vests (relative frequency)*	92%
Question 6	Miguel says, "I am 80% sure the Warriors won last night." *is trying to recall the outcome of the game that he read in the newspaper (feeling of knowing)* Noah says, "I think there is an 80% chance the Warriors won last night."	85%
Question 7	Emily says: "I'm 70% sure Brian parked his car in Lot C today." Sabrina says, "I think there is a 70% chance Brian parked his car in Lot C today." *is thinking "Brian parks in Lot C on most days" (relative frequency)*	61%
Question 8	Mr. and Mrs. Adams say, "We are 90% sure we are going to have a baby in the next few years." *are uncertain about their decision to conceive (internal control)* Mr. and Mrs. Bing say, "We think there is a 90% chance we will have a baby in the next few years." *are uncertain about their ability to conceive (external control)*	74%
Question 9	Suzanne says, "I am 60% sure my new restaurant will be profitable." *thinks that success depends mostly on individual effort and ability (internal control)* Wendy says, "I think there is a 60% chance my new restaurant will be profitable." *thinks that success depends mostly on factors outside of one's control (external control)*	91%
Question 10	Colin says, "I am 70% sure I'll win the poker tournament." *is thinking about his own poker skill (internal control)* Shane says, "I think there is a 70% chance I'll win the poker tournament." *is thinking about the poker skill of all players in the tournament (external control)*	83%

Note. For Items 3, 4, 6, and 7, participants matched a single rationale to one of two uncertainty statements; for the remaining items, participants matched two rationales each to one of two uncertainty statements. Rationale categories (in parentheses) are displayed here for exposition purposes and were not presented to participants.
[a] The second column includes confidence and likelihood statements used in Study 3, listed with epistemic and aleatory uncertainty-related rationales, respectively, for each question. [b] Numbers in the third column indicate the proportion of respondents who matched rationale(s) for a given question in a hypothesis-consistent manner.

ment with singular forms of reasoning, and the likelihood statement with distributional forms of reasoning.

Turning to participants' profiles of responses across items, the mean number of rationales matched to the predicted language was 7.78 out of 10 possible items, which is significantly larger than a random match rate of 5.00, $t(104) = 10.08$, $p < .001$. At the individual participant level, we find that 91% of participants matched most of the rationales (i.e., at least 6 out of 10) to the predicted language ($p < .001$ by sign test).

Discussion

The results of Study 3 support our hypothesis that when speakers choose confidence statements, listeners tend to infer that the speaker is relying on singular reasoning, feeling-of-knowing, or believe themselves to have some control over the event in question (so that the outcomes appear in some sense to be more fundamentally knowable). In contrast, when a statement is conveyed using likelihood language, listeners infer that the speaker is relying on distributional reasoning, relative frequency information, or believes that control over the event is primarily outside of themselves (so that the outcomes appear to be more inherently random). This pattern of results supports the notion that listeners, like speakers, intuitively distinguish uncertainty that is in principle knowable (epistemic) from uncertainty that is inherently random or stochastic (aleatory) and that this distinction is reflected in their understanding of language.

One limitation of Studies 1–3 is that they are correlational and do not show a causal relationship between language use and conceptions of uncertainty. We next turn to two studies that attempt to trigger thoughts about epistemic versus aleatory uncertainty using confidence versus likelihood statements.

Study 4: Epistemic Versus Aleatory Stems Influence Sentence Completions

Our primary assertion in this article is that people systematically favor confidence language to communicate (primarily) epistemic uncertainty and likelihood language to communicate (primarily) aleatory uncertainty. This suggests that thoughts about uncertainty can influence choice of language, and it raises the intriguing question of whether the choice of language can likewise influence thoughts about these forms of uncertainty. In Study 4, we test this notion by providing participants with dependent clauses (stems) that contain either confidence statements or likelihood statements, and then asking participants to complete these stems with any event that naturally occurs to them and sounds natural completing the sentence. We predicted that confidence stems would be completed more frequently with events reflecting epistemic uncertainty and likelihood stems would be completed more frequently with events reflecting aleatory uncertainty.

Method

We recruited 374 participants from Amazon's Mechanical Turk platform (43% female, average age = 33 years) to complete a 5-min study in exchange for $0.50. We presented participants with sentence stems and asked them to complete each stem ". . . with an event so that the complete sentence sounds natural to you." Every

participant completed two confidence stems and two likelihood stems. For half the participants, the confidence stems were "sure" (e.g., "I am 60% sure that ____"), and the likelihood stems were "chance" (e.g., "I think there is 60% chance that ____"). For the other half of participants the confidence stems were "confident" and the likelihood stems were "probability." For every participant, one confidence stem and one likelihood stem were quantified by 60% (e.g., "60% sure" or "60% chance"), and the remaining stems were quantified by 80%. The order of presentation of the confidence and likelihood stems, and the order of presentation of the percentages were counterbalanced.

After the sentence completion task, we provided the participants with the four events they had entered (without the stems), and asked them to self-rate each event on a four-item version of the EARS (Fox et al., 2016; see Supplementary Materials). We calculated a self-rated composite EARS measure by subtracting each participant's average score on the aleatory subscale from his or her average score on the epistemic subscale.[11]   **Fn11**

Results

We conducted a regression model predicting the self-rated composite EARS score from dummy variables indicating (a) confidence versus likelihood stem, (b) stem variant (i.e., sure or confident for confidence stems; chance or probability for likelihood stems), (c) two order variables, and (d) probability level (i.e., either 60% or 80%), as presented in Table 7. Confirming our prediction, **T7** we observed a significant main effect of confidence/likelihood stems ($B = .447$, $p < .001$), with confidence stems prompting participants to complete sentences using events that they subsequently rated higher in epistemic uncertainty (and lower in aleatory uncertainty). The only other significant result from this regression was for probability level ($B = -.685$, $p < .001$), suggesting that higher subjective probabilities brought to mind events that were subsequently rated as more epistemic (and less aleatory).

While participants' ratings of their own sentence completions might be viewed as particularly valid, one might be concerned that some participants recalled from the previous screen the stem that prompted the relevant sentence completion; if so, this may have affected EARS ratings. Thus, to test the robustness of the foregoing results, we asked two independent, condition-blind, and hypothesis-blind judges to rate all sentence completions, presented in a scrambled order and without corresponding stems, on the four-item EARS. We observed a moderately high correlation between judges on this composite score, $r = .66$, $p < .000$, and therefore averaged the two judges' score for each sentence completion. Running the same regression model as described above, this time using judge-rated rather than self-rated EARS score, reveals qualitatively identical results (see Table 7).

Discussion

Study 4 confirms our prediction that confidence statements (e.g., "I am 60% sure that . . .") prompt respondents to think about events

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[11] We used a composite measure of EARS rather than separate subscales, because unlike Study 2A, in this study, we are using EARS score as a dependent variable.

Table 7
Predicting Self-Rated and Judge-Rated EARS Scores

Dependent variable	Predictors	B	SE	Wald χ^2	p Value	R^2
Self-rated composite EARS score	Confidence/likelihood	.447	.117	14.58	<.001	
	Stem type	.170	.155	1.205	.272	
	Percent order	.106	.153	.476	.490	
	Stem order	−.131	.155	.712	.399	
	Probability dummy	.685	.119	33.349	<.001	
						.029
Judge-rated composite EARS score	Confidence/likelihood	.796	.107	55.080	<.001	
	Stem type	.015	.119	.016	.900	
	Percent order	.006	.119	.003	.957	
	Stem order	−.167	.119	1.972	.160	
	Probability dummy	.416	.105	15.684	<.001	
						.046

Note. EARS = Epistemic–Aleatory Rating Scale. For the composite EARS score (Epistemic - Aleatory), higher numbers indicate more Epistemicness and/or less Aleatoriness.

that involve more epistemic and less aleatory uncertainty compared to likelihood statements (e.g., "I think there is a 60% chance that . . ."). We note that the significant influence of subjective probability level on EARS ratings that we observed in Study 4, while not a central concern of the present article, echoes the impact of subjective probability on choice of language that we observed in Studies 2A and 2B. This said, we were careful in the studies described in this article to statistically control for probabilities among other factors (Studies 2A, 2B, and 4) or hold numbers constant across statement types (Study 3). For more on the relationship between variants of uncertainty and judgment extremity, see Tannenbaum, Fox, and Ülkümen (in press).

Study 5: Language Prompts Differential Weighting of Evidence

Study 4 established that confidence statements can trigger relatively epistemic thinking and likelihood statements can trigger relatively aleatory thinking. In Study 5, we examine whether exposure to these statements can induce people to differentially weight epistemic versus aleatory information when evaluating their degree of uncertainty. We exposed participants to cues that might help them predict a hypothetical event and asked them to estimate their subjective probability using either a confidence or a likelihood frame. One cue concerned an intuitive feeling-of-knowing (epistemic uncertainty), and the other cue concerned relative frequency (aleatory uncertainty). We predicted that participants would make more use of the cue that is most compatible with the linguistic frame in which they were estimating probabilities. Thus, if the confidence frame highlights epistemic uncertainty, then information that is relevant to such uncertainty (a feeling-of-knowing cue) should receive greater weight in that frame. Conversely, if the likelihood frame highlights aleatory uncertainty, then information that is relevant to such uncertainty (a relative frequency cue) should receive greater weight in that frame.

Method

We recruited 299 University of California, Los Angeles, undergraduate students to participate in a study that included a number of unrelated surveys compiled in a rotated order, in exchange for a fixed payment. Our task entailed quantifying uncertainty concerning a hypothetical event: whether a hypothetical friend, Tom, was wearing a cap the previous day. Participants were presented with two pieces of information: one sentence containing feeling-of-knowing information and one sentence containing base-rate information. Feeling-of-knowing information was manipulated to be either low in diagnosticity ("You were in the same large lecture class with your friend Tom yesterday, and you have the vague sense that he might have been wearing a cap"), or high in diagnosticity ("You were in the same large lecture class with your friend Tom yesterday, and you have the impression that he was wearing a cap"). Likewise, base rate information was manipulated to be either low ("Your friend Tom wears a cap a few times a week"), or high ("Your friend Tom wears a cap almost every day"). After reading these two sentences, roughly half of participants assessed probability by completing a sentence that used a confidence stem ("I am _____% sure that Tom was wearing a cap yesterday") and the remaining participants completed a sentence that used a likelihood stem ("I'd say there is a _____% chance that Tom was wearing a cap yesterday").

Results

Mean judged probabilities by condition are displayed in Figure 2. To begin with, a 2 (Language Prompt: confidence, likelihood) × 2 (Epistemic Information: low, high) × 2 (Aleatory Information: low, high) analysis of variance revealed no main effect of the language prompt, $F(1, 291) = 2.161$, $p > .1$, suggesting that the "sure" and "chance" scales were used in a similar manner by respondents. Not surprisingly, we found a main effect of epistemic information, $F(1, 291) = 17.02$, $p < .001$, $\omega^2 = 0.05$, and a main effect of aleatory information, $F(1, 291) = 76.12$, $p < .001$, $\omega^2 = 0.20$, where higher levels of both types of information led to higher probability estimates—providing a successful manipulation check of these variables.

More importantly, and confirming our first prediction, we observed a significant interaction between epistemic information and language prompt, $F(1, 291) = 8.81$, $p < .005$, $\omega^2 = 0.03$, suggesting that the impact of epistemic information is stronger when people quantified confidence stems (vs. likelihood stems; see Figure 2, Panel A). Confirming our second prediction, there was a
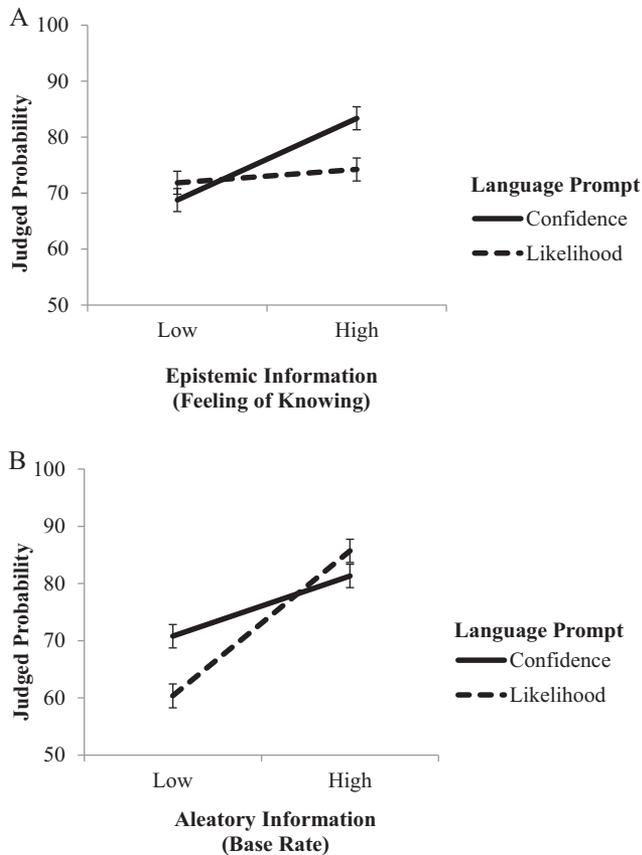
Figure 2. Sensitivity to epistemic and aleatory cues for each language prompt in Study 5.

significant and complementary interaction between aleatory information and language prompt, $F(1, 291) = 12.97$, $p < .001$, $\omega^2 = 0.04$, suggesting that the impact of aleatory information is stronger when people quantified likelihood (vs. confidence) stems (see Figure 2, Panel B).

Discussion

Results of Study 5 confirm our predictions and lend further support to the notion that confidence statements can induce greater sensitivity to information that relates to epistemic uncertainty whereas likelihood statements can induce greater sensitivity to information that relates to aleatory uncertainty. This suggests that subtle variation in the language chosen to frame a person's quantification of uncertainty can strongly influence the cognitive process underlying that judgment.

General Discussion

In this article, we presented six studies that collectively provide compelling evidence that people intuitively distinguish epistemic (knowable) uncertainty from aleatory (random) uncertainty in their use of natural language. In particular, both speakers and listeners tend to associate confidence statements (e.g., "I am 80% sure that . . ." or "I am reasonably confident that . . .") with epistemic

uncertainty and likelihood statements (e.g., "I think there is an 80% chance that . . ." or "I believe there is a high probability that . . .") with aleatory uncertainty. In Study 1, we examined every relevant article that appeared in the *New York Times* over a 2-year period and found that confidence statements were strongly associated with features of epistemic uncertainty, whereas likelihood statements were strongly associated with features of aleatory uncertainty. In Study 2A, we showed that people explicitly choose confidence statements over likelihood statements to express their uncertainty about events that they perceive to be more epistemic and less aleatory, controlling for subjective probability and whether the statement refers to self-relevant events or events in the world. In Study 2B, we showed that people who express more internal locus of control (Rotter, 1966) are more apt to choose confidence statements over likelihood statements when predicting events about themselves (over which they might plausibly exert some control), but not for events about the external world (for which they do not have plausible control). In Study 3, we showed that listeners reliably match confidence statements with singular reasoning, a feeling of knowing, and internal control; conversely, they match likelihood statements with distributional reasoning, relative frequency information, and external control. In Study 4, we observed that people tend to complete confidence statements with more epistemic events and they tend to complete likelihood statements with more aleatory events. Finally, in Study 5, we showed that while the numbers that people use to quantify confidence (% sure) and likelihood (% chance) statements do not appear to differ overall, people tend to express greater sensitivity to feeling-of-knowing information and less sensitivity to relative frequency information when quantifying confidence statements rather than likelihood statements, and people exhibit the opposite relative sensitivities when quantifying likelihood statements rather than confidence statements.

Implications

The present results have a number of important theoretical, methodological, and practical implications. Theoretically, our results suggest that people intuitively distinguish two dimensions of subjective uncertainty, consistent with the classification advanced by Fox & Ülkümen (2011). Second, our results highlight a critical linguistic attribute that has thus far been overlooked in the risk and uncertainty communication literatures: whether a statement is expressed in a confidence or likelihood language format. Third, we contribute a new data point to the debate in psycholinguistics concerning the relationship between language and thought: Our results suggest that the relationship in this context is bidirectional so that language use can not only arise from a cognitive distinction that people naturally make (as in Studies 1–3) but it can also induce this distinction (as in Studies 4–5).

Methodologically, our results suggest that the language format in which probabilistic beliefs are elicited can have a critical impact on the weighting of evidence, violating a common assumption of procedure invariance. In particular, our results from Study 5 would suggest that when subjective probabilities are elicited as a degree of confidence (0–100%), respondents may attend more to epistemic information (e.g., feeling-of-knowing, representativeness), but when subjective probabilities are elicited as a rating of likelihood (0–100%), respondents may attend more to aleatory infor-

mation (e.g., relative frequency, availability of instances). Thus, researchers ought to be mindful of the potentially biasing effect of confidence versus likelihood formats when eliciting subjective probabilities. Perhaps more important, because assessments of epistemic versus aleatory uncertainty can differ across individuals, domains, and occasions, researchers should be cautious in generalizing results from one context to another.

Practically, our results suggest that speakers ought to be more mindful of what they may unintentionally communicate through their choice of confidence versus likelihood statements. For instance, if a professor tells a prospective student that she is "80% sure" that the student will be admitted to a doctoral program, the student may infer that the professor has more influence than if the same professor had communicated that there is an "80% chance." Likewise, listeners ought to be careful to verify their assumptions about what is being communicated by uncertainty statements. For instance, when an expert witness says, "I'm 90% sure the biometric evidence matches the suspect," listeners may naturally surmise a singular judgment whose persuasiveness depends on the witness' perceived expertise, whereas if that same witness says, "I'd say there is a 90% chance the biometric data match the suspect," listeners may naturally surmise a statistical model that derives from external sources or algorithms and therefore depends less on expertise.

Choice of confidence versus likelihood statements may affect the credibility of advice. In continuing (unpublished) work, we find that people prefer to follow the recommendation of a speaker who expresses himself using a confidence statement, provided the speaker possesses sufficient expertise to construct an appropriate singular model. For instance, most respondents said they would prefer to submit an essay to a literary journal whose editor said he or she was "80% sure" the journal would publish the essay if submitted than to a similar journal whose editor said, "I think there is an 80% chance" the journal would publish the essay if submitted. However, this effect diminished significantly if the same statements were made by mail clerks at the respective journals.

Choice of confidence versus likelihood statements also appears to influence how forecasters are evaluated. Research validating the EARS suggests that when observers see uncertainty as more epistemic they assign more credit for correct predictions and blame for incorrect predictions; when observers see uncertainty as more aleatory, they see correct predictions as more lucky and incorrect predictions as unlucky (Fox et al., 2016). Indeed, we find that our participants say that an executive who makes a forecast as a confidence statement (e.g., "I am 70% sure that sales will increase") is more likely to be promoted if correct and more likely to be fired if incorrect than a speaker who makes the same forecast using a likelihood statement (e.g., "I believe there is a 70% chance that sales will increase"). Moreover, language may be used strategically to manage impressions. In unpublished data, Fox et al. (2016) examine transcripts of earnings calls from more than 1,000 companies listed on American stock exchanges, and they observe a higher frequency of aleatory-related words (e.g., "chance," "probability," "distribution") when earnings fall short of analysts' forecasts than when earnings exceed analysts' forecasts; meanwhile, these reports indicate a higher frequency of epistemic-related words (e.g., "sure," "suppose," "model") when earnings exceed analysts' forecasts than when earnings fall short of analysts' forecasts.

AQ: 3

A Semantic or Cognitive Distinction?

A question that naturally arises is whether the mapping between confidence versus likelihood expressions and epistemic versus aleatory uncertainty is merely a linguistic convention or whether it also reflects distinct cognitive processes associated with these variants of uncertainty. We assert that many of the results reported in this article suggest that these dimensions of uncertainty are indeed associated with distinct cognitive strategies. Perhaps the strongest evidence comes from Study 5 in which we show that when judging probabilities people afford greater weight to evidence that is congruent with the linguistic frame (% chance vs. % sure). Moreover, Study 2B shows that chronic individual differences in people's perception of how much control they have over outcomes (and presumably therefore how predictable those outcomes are) is systematically related to their choice of language, suggesting an underlying cognitive distinction. As for the listener's perspective, Study 3 shows that listeners infer that speakers who use epistemic language rely on singular reasoning, feeling-of-knowing, and perceive internal control of outcomes, whereas they infer that speakers who use aleatory language rely on distributional reasoning, relative frequencies, and perceive external control of outcomes. This suggests that listeners' mental models of speakers' reasoning are affected by speakers' choice of language.

If the epistemic–aleatory distinction is a universal cognitive one, this might suggest that the linguistic distinction between confidence and likelihood statements should generalize across many languages. Anecdotally, the first author, a native Turkish speaker, readily identifies a distinction between "emin," a confidence statement, and "olasilik," a likelihood statement. The third author, a native German speaker, likewise identifies a distinction between "überzeugt" and "wahrscheinlich." Moreover, when we conducted informal structured interviews with students on the USC campus whose native languages were Amharic (Ethiopia), Chinese, Danish, Igbo (Nigeria), Indonesian, Latvian, Marathi (India), Russian, Sinhala (Sri Lanka), and Spanish, all students easily identified in their native language distinct confidence and likelihood terms.

Further evidence for the notion that people routinely make a cognitive distinction between epistemic and aleatory uncertainty comes from parallel projects in nonlinguistic domains. As previously mentioned, we find that perceived epistemicness and aleatoriness independently predict credit/blame and luckiness/unluckiness of correct/incorrect forecasts, respectively (Fox et al., 2016), and people make more extreme probability judgments for events they see as more epistemic and less aleatory (Tannenbaum et al., in press). Moreover, we find that investors who see the stock market as more epistemic tend to diversify less, trade more often, and value financial advice more highly (Walters, Ülkümen, Erner, Tannenbaum, & Fox, 2016).

Finally, the cognitive distinction between epistemic and aleatory uncertainty may be particularly relevant to the decision theoretic distinction between decision under risk, in which outcome probabilities are known precisely, and decision under uncertainty, in which they are not (Knight, 1921). Risk might be viewed as entailing pure aleatory uncertainty and no epistemic uncertainty (i.e., utmost confidence in the probability distribution over outcomes), whereas Knightian uncertainty might be viewed as entailing some epistemic uncertainty (i.e., lack of total confidence in one's impression of that distribution). Thus, ambiguity aversion

(Ellsberg, 1961), the preference to act in situations where probabilities are clear rather than vague, might be seen as reluctance to act in situations involving a greater degree of epistemic uncertainty, a conclusion that appears to be borne out by studies of the competence and comparative ignorance effects (Chow & Sarin, 2002; Fox & Tversky, 1995; Fox & Weber, 2002; Hadar, Sood, & Fox, 2013; Heath & Tversky, 1991).

Why Do People Distinguish Variants of Uncertainty?

In addition to our observations about natural language use, a number of prior studies suggest that an intuitive distinction between variants of uncertainty may be innate. For instance, 4–6-year-old children appear to make different choices when facing chance events yet to occur (in which aleatory uncertainty is presumably salient) versus chance events that have already been resolved but not yet revealed to them (in which epistemic uncertainty is presumably salient; Robinson, Rowley, Beck, Carroll, & Apperly, 2006). Meanwhile, brain imaging studies (Volz, Schubotz, & von Cramon, 2005; 2004) have found distinct activation patterns when participants make decisions concerning events whose outcomes are determined by fixed rules that have been imperfectly learned (for which epistemic uncertainty is presumably salient) compared to similar events for which a probabilistic pattern has been well learned (for which aleatory uncertainty is presumably salient).

We speculate that people distinguish variants of uncertainty because doing so serves an important adaptive function of helping them identify distinct strategies for assessing and reducing uncertainty they face in the world. In terms of assessing uncertainty, the epistemic strategies entail metacognitive evaluation of one's confidence in a case that is knowable or predictable or for which a true answer exists. Such strategies may rely on an assessment of the adequacy of one's memory, fluency of an explanation or model, representativeness of evidence with one's model of the world, or credibility of a source. In contrast, aleatory strategies entail an assessment of relative frequency of a class of events that is treated as random or unpredictable or for which many possible realizations are possible. Such strategies may rely on counting, availability in memory of instances, or explicit calculation. In terms of reducing uncertainty, epistemic strategies may include looking for patterns, associations, causes, and/or seeking clinical expertise. Meanwhile, aleatory strategies may include looking for additional data or empirical regularities, and/or seeking statistical expertise.

Future Directions

We see several promising directions for future research on the distinction between confidence and likelihood statements. For instance, in ongoing research we find that when equivalent predictions are in opposing directions (e.g., one expert says, "I am 60% sure that Team A will beat Team B," and another expert says, "I think there is a 60% chance that Team B will beat team A"), listeners tend to favor the judgment expressed as a confidence statement, and this effect appears to be stronger when both speakers have greater expertise (presumably because validity of a singular model is more sensitive to expertise than validity of a distributional model). Second, in continuing work we find that speakers who express probabilistic beliefs as confidence state-

ments are assigned more credit if right and more blame if wrong, compared to speakers who express the same numerical probabilities as likelihood statements. This result is consistent with concurrent work showing that when judges perceive relevant uncertainty to be more epistemic, they assign forecasters more credit (blame) for correct (incorrect) statements (Fox et al., 2016).

The analysis of confidence versus likelihood statements shows a great deal of promise for future research. Although we restrict our attention to the most common English expressions of subjective belief that can be quantified ("sure," "confident," and "certain" vs. "chance," "likely/likelihood," and "probability"), we acknowledge that these six terms are not exhaustive representatives of the putative "confidence" and "likelihood" stem categories and that we have not yet thoroughly tested all linguistic variations. Moreover, although we studied multiple instantiations of confidence and likelihood stems in Studies 1 and 4, in other studies we relied on the most commonly used exemplars: "% sure" and "% chance." An important next step in advancing this work will be to develop and test a more extensive lexicon of epistemic versus aleatory expressions in natural language. Such a lexicon can be used as a flexible tool for exploring lay distinctions between variants of uncertainty that are manifested in natural environments including domains of financial, legal, medical, and political discourse.

Our main goal in this article is to provide behavioral evidence that people intuitively distinguish two variants of uncertainty in ways that are marked by two distinct groups of verbal expressions. While the present investigation is guided by Fox & Ülkümen's (2011) framework and we focus on confidence versus likelihood formats, we acknowledge that our data may lend support to alternative conceptualizations of variants of uncertainty and that there are several additional dimensions on which verbal expressions of uncertainty can be characterized. For instance, Kahneman and Tversky (1982) assert that objective versus subjective tone (e.g., "*The* probability is X%" vs. "*My* probability is X%") may (imperfectly) distinguish external versus internal locus of uncertainty in their framework. Likewise, Løhre & Teigen (in press) present a series of studies suggesting that passive third person markers (e.g., "It is X% certain") versus active first person markers (e.g., "I am X% certain") may promote the perception of external versus internal uncertainty. As mentioned, whereas aleatory uncertainty is inherently distributional and therefore tends to be external, the epistemic–aleatory distinction is logically independent from the internal–external distinction. Indeed, Fox & Ülkümen (in press) report a variation of Study 4 from the present article in which they crossed confidence versus likelihood stems with objective versus subjective tone and then asked participants to complete sentences with events so that they sound natural. Participants next coded their own sentence completions on various dimensions. Results suggested that subjective language (e.g., "I am fairly certain that . . .") versus objective language (e.g., "It is fairly certain that . . .") prompts respondents to think about internal versus external uncertainty, respectively (but not necessarily epistemic vs. aleatory uncertainty). In contrast, they find that confidence language (e.g., "I am fairly certain that . . .") versus likelihood language (e.g., "I'd say there is a high probability that . . .") tends to prompt respondents to think about epistemic versus aleatory uncertainty, respectively (but not necessarily internal vs. external uncertainty). Naturally, there is much more work yet to be done to clarify all of the relevant dimensions of linguistic expressions and determine how

they interact with one another and map onto variants of uncertainty.

References

Ang, A. H. S., & Tang, W. H. (2006). *Probability concepts in engineering: Emphasis on applications in civil and environmental engineering* (second ed.). New York, NY: Wiley.

Azen, R., & Budescu, D. V. (2003). The dominance analysis approach for comparing predictors in multiple regression. *Psychological Methods, 8,* 129–148. http://dx.doi.org/10.1037/1082-989X.8.2.129

Azen, R., & Traxel, N. (2009). Using dominance analysis to determine predictor importance in logistic regression. *Journal of Educational and Behavioral Statistics, 34,* 319–347. http://dx.doi.org/10.3102/1076998609332754

Boas, F. (1966). Introduction. In F. Boas (Ed.), *Handbook of American Indian languages* (reprint edited by P. Holder; pp. 1–79). Lincoln, NE: University of Nebraska Press.

Brun, W., & Teigen, K. H. (1988). Verbal probabilities: Ambiguous, context-dependent, or both? *Organizational Behavior and Human Decision Processes, 41,* 390–404. http://dx.doi.org/10.1016/0749-5978(88)90036-2

Budescu, D. V. (1993). Dominance analysis: A new approach to the problem of relative importance of predictors in multiple regression. *Psychological Bulletin, 114,* 542–551. http://dx.doi.org/10.1037/0033-2909.114.3.542

Budescu, D. V., & Wallsten, T. S. (1985). Consistency in interpretation of probabilistic phrases. *Organizational Behavior and Human Decision Processes, 36,* 391–405. http://dx.doi.org/10.1016/0749-5978(85)90007-X

Chapman, S. (2000). *Philosophy for Linguists: An Introduction.* London, United Kingdom: Routledge. http://dx.doi.org/10.4324/9780203459492

Chow, C. C., & Sarin, R. K. (2002). Known, unknown, and unknowable uncertainties. *Theory and Decision, 52,* 127–138. http://dx.doi.org/10.1023/A:1015544715608

Dequech, D. (2004). Uncertainty: Individuals, institutions and technology. *Cambridge Journal of Economics, 28,* 365–378. http://dx.doi.org/10.1093/cje/28.3.365

Druzdzel, M. J. (1989). *Verbal uncertainty expressions: Literature review. Tech. Rep. No., CMU-EPP-1990–03-02.* Pittsburgh, PA: Department of Engineering and Public Policy, Carnegie Melon University.

Ellsberg, D. (1961). Risk, ambiguity, and the Savage axioms. *The Quarterly Journal of Economics, 75,* 643–669. http://dx.doi.org/10.2307/1884324

Fox, C. R., & Irwin, J. R. (1998). The role of context in the communication of uncertain beliefs. *Basic and Applied Social Psychology, 20,* 57–70. http://dx.doi.org/10.1207/s15324834basp2001_6

Fox, C. R., Tannenbaum, D., Ülkümen, G., Walters, D., & Erner, C. (2016). *Skill versus luck and attributions of uncertainty: Validating an Epistemic–aleatory Rating Scale (EARS).* Manuscript submitted for publication.

Fox, C. R., & Tversky, A. (1995). Ambiguity aversion and comparative ignorance. *The Quarterly Journal of Economics, 110,* 585–603. http://dx.doi.org/10.2307/2946693

Fox, C. R., & Ülkümen, G. (2011). Distinguishing two dimensions of uncertainty. In W. Brun, G. Kirkebøen, & H. Montgomery (Eds.), *Essays in judgment and decision making.* Oslo, Norway: Universitetsforlaget.

AQ: 6 Fox, C. R., & Ülkümen, G. (in press). Variants of language and variants of uncertainty: A response to Løhre & Teigen. *Thinking & Reasoning.*

Fox, C. R., & Weber, M. (2002). Ambiguity aversion, comparative ignorance, and decision context. *Organizational Behavior and Human Decision Processes, 88,* 476–498. http://dx.doi.org/10.1006/obhd.2001.2990

Gelman, R., & Gallistel, C. R. (2004). Language and the origin of numerical concepts. *Science, 306,* 441–443. http://dx.doi.org/10.1126/science.1105144

Gentner, D., & Goldin-Meadow, S. (Eds.). (2003). *Language in mind: Advances in the study of language and thought.* Cambridge, MA: MIT Press.

Gilovich, T., Griffin, D., & Kahneman, D. (2002). *Heuristics and biases: The psychology of intuitive judgement.* Cambridge, United Kingdom: Cambridge University Press. http://dx.doi.org/10.1017/CBO9780511808098

Gleitman, L., & Papafragou, A. (2013). New perspectives on language and thought. In K. J. Holyoak & R. G. Morrison (Eds.), *The Oxford handbook of thinking and reasoning* (pp. 543–568). Oxford, United Kingdom: Oxford University Press.

Hacking, I. (1975). *The Emergence of probability: A philosophical study of early ideas about probability, induction and statistical inference.* New York, NY: Cambridge University Press.

Hadar, L., Sood, S., & Fox, C. R. (2013). Subjective knowledge in consumer financial decisions. *Journal of Marketing Research, 50,* 303–316. http://dx.doi.org/10.1509/jmr.10.0518

Heath, C., & Tversky, A. (1991). Preference and belief: Ambiguity and competence in choice under uncertainty. *Journal of Risk and Uncertainty, 4,* 5–28. http://dx.doi.org/10.1007/BF00057884

Howell, W., & Burnett, S. A. (1978). Uncertainty measurement: A cognitive taxonomy. *Organizational Behavior and Human Performance, 22,* 45–68. http://dx.doi.org/10.1016/0030-5073(78)90004-1

Juanchich, M., Teigen, K. H., & Gourdon, A. (2013). Top scores are possible, bottom scores are certain (and middle scores are not worth mentioning): A pragmatic view of verbal probabilities. *Judgment and Decision Making, 8,* 345–364.

Kahneman, D., Slovic, P., & Tversky, A. (1982). *Judgment under uncertainty: Heuristics and biases.* New York, NY: Cambridge University Press. http://dx.doi.org/10.1017/CBO9780511809477

Kahneman, D., & Tversky, A. (1982). Variants of uncertainty. *Cognition, 11,* 143–157. http://dx.doi.org/10.1016/0010-0277(82)90023-3

Kahneman, D., & Tversky, A. (Eds.). (2000). *Choices, values and frames.* New York, NY: Cambridge University Press.

Keren, G. (1991). Calibration and probability judgments: Conceptual and methodological issues. *Acta Psychologica, 77,* 217–273. http://dx.doi.org/10.1016/0001-6918(91)90036-Y

Keren, G., & Wu, G. (Eds.). (2015). *The Wiley-Blackwell handbook of judgment and decision making.* West Sussex, United Kingdom: Wiley. http://dx.doi.org/10.1002/9781118468333

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

Koehler, D., & Harvey, N. (Eds.). (2004). *Blackwell handbook of judgment and decision making.* Oxford, UK: Blackwell. http://dx.doi.org/10.1002/9780470752937

Lichtenstein, S., & Newman, J. R. (1967). Empirical scaling of common verbal phrases associated with numerical probabilities. *Psychonomic Science, 9,* 563–564. http://dx.doi.org/10.3758/BF03327890

Locke, J. (1824). *The works of John Locke in nine volumes, Book III* (12th ed.). London, UK: Rivington.

Løhre, E., & Teigen, K. H. (in press). There is a 60% probability but I am 70% certain: Communicative consequences of external and internal expressions of uncertainty. *Thinking & Reasoning.*

Losonsky, M. (Ed.). (1999). *Humboldt: "On language": On the diversity of human language construction and its influence on the mental development of the human species* Cambridge, UK: Cambridge University Press.

Monti, M. M. (in press). The role of language in structure-dependent cognition. In M. Moody (Ed.), *Neural mechanisms of language.* New AQ: 9 York, NY: Springer.

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

Oberkampf, W. L., Helton, J. C., Joslyn, C. A., Wojtkiewicz, S. F., & Ferson, S. (2004). Challenge problems: Uncertainty in system response given uncertain parameters. *Reliability Engineering & System Safety, 85,* 11–19. http://dx.doi.org/10.1016/j.ress.2004.03.002

Olson, M. J., & Budescu, D. V. (1997). Patterns of preference for numerical and verbal probabilities. *Journal of Behavioral Decision Making, 10,* 117–131. http://dx.doi.org/10.1002/(SICI)1099-0771(199706)10:2<117::AID-BDM251>3.0.CO;2-7

Peterson, D. K., & Pitz, G. F. (1988). Confidence, uncertainty, and the use of information. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14,* 85–92. http://dx.doi.org/10.1037/0278-7393.14.1.85

Robinson, E. J., Rowley, M. G., Beck, S. R., Carroll, D. J., & Apperly, I. A. (2006). Children's sensitivity to their own relative ignorance: Handling of possibilities under epistemic and physical uncertainty. *Child Development, 77,* 1642–1655. http://dx.doi.org/10.1111/j.1467-8624.2006.00964.x

Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. *Psychological Monographs, 80,* 1–28. http://dx.doi.org/10.1037/h0092976

Rowe, W. D. (1994). Understanding uncertainty. *Risk Analysis, 14,* 743–750. http://dx.doi.org/10.1111/j.1539-6924.1994.tb00284.x

Smith, G. F., Benson, P. G., & Curley, S. P. (1991). Belief, knowledge, and uncertainty: A cognitive perspective on subjective probability. *Organizational Behavior and Human Decision Processes, 48,* 291–321. http://dx.doi.org/10.1016/0749-5978(91)90016-M

Smithson, M. (1989). *Ignorance and uncertainty: Emerging paradigms.* New York, NY: Springer-Verlag Publishing. http://dx.doi.org/10.1007/978-1-4612-3628-3

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 & Medicine, 32,* 725–731. http://dx.doi.org/10.1016/0277-9536(91)90152-3

Tannenbaum, D., Fox, C. F., & Ülkümen, G. (in press). Judgment extremity and accuracy under epistemic vs. aleatory uncertainty. *Management Science.*

Teigen, K. H. (1994). Variants of subjective probabilities: Concepts, norms, and biases. In G. Wright & P. Ayton (Eds), *Subjective probability* (pp. 211–238). Oxford, England: Wiley.

Volz, K. G., Schubotz, R. I., & von Cramon, D. Y. (2004). Why am I unsure? Internal and external attributions of uncertainty dissociated by fMRI. *NeuroImage, 21,* 848–857. http://dx.doi.org/10.1016/j.neuroimage.2003.10.028

Volz, K. G., Schubotz, R. I., & von Cramon, D. Y. (2005). Variants of uncertainty in decision-making and their neural correlates. *Brain Research Bulletin, 67,* 403–412. http://dx.doi.org/10.1016/j.brainresbull.2005.06.011

Wallsten, T. S., Budescu, D. V., Erev, I., & Diederich, A. (1997). Evaluating and combining subjective probability estimates. *Journal of Behavioral Decision Making, 10,* 243–268. http://dx.doi.org/10.1002/(SICI)1099-0771(199709)10:3<243::AID-BDM268>3.0.CO;2-M

Wallsten, T. S., Fillenbaum, S., & Cox, J. A. (1986). Base rate effects on the interpretation of probability and frequency expressions. *Journal of Memory and Language, 25,* 571–587. http://dx.doi.org/10.1016/0749-596X(86)90012-4

Walters, D., Ülkümen, G., Erner, C., Tannenbaum, D., & Fox, C. (2016). *Perceived nature of market uncertainty predicts investment behaviors.* (Working paper). Los Angeles, CA: UCLA Anderson School of Management.

Weber, E. U., & Hilton, D. J. (1990). Contextual effects in the interpretations of probability words: Perceived base rate and severity of events. *Journal of Experimental Psychology: Human Perception and Performance, 16,* 781–789. http://dx.doi.org/10.1037/0096-1523.16.4.781

Whorf, B. L. (1956). *Language, thought, and reality: Selected writings of Benjamin Lee Whorf* (Ed. J. B. Carroll). Cambridge, MA: The MIT Press. (Original work written 1927–1941).

AUTHOR QUERIES

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