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RESEARCH REPORT

Communicating Environmental Risks: Clarifying the Severity Effect in Interpretations of Verbal Probability Expressions

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Verbal probability expressions are frequently used to communicate risk and uncertainty. The Intergovernmental Panel on Climate Change (IPCC), for example, uses them to convey risks associated with climate change. Given the potential for human action to mitigate future environmental risks, it is important to understand how people respond to these expressions. In 3 studies employing a novel manipulation of event severity (so as to avoid any confound with event base rate), we demonstrated a systematic effect of event severity on the interpretation of verbal probability expressions. Challenging a previous finding in the literature, expressions referring to a severe event were interpreted as indicating a higher probability than those referring to a more neutral event. The finding was demonstrated in scenarios communicating risks relating to climate change (Studies 1 and 2) and replicated in scenarios involving nanotechnology and nuclear materials (Study 3). This is the first direct demonstration of an effect of outcome severity on the interpretation of verbal probability expressions, correcting a previous (potentially problematic) conclusion attributable to a flawed experimental design.

Keywords: risk communication, risk perception, environmental risk, verbal probability expressions, severity effect

By definition, risk information relates to outcomes about which we have less than perfect information. Both mundane ("Should I carry an umbrella to work?") and consequential ("Should millions be spent on reducing carbon emissions?") decisions must frequently be made on the basis of probabilistic forecasts (the likelihood of rain, the likelihood of carbon emissions having a serious adverse effect on the planet). Despite a great deal of research on risk perception and communication (see e.g., Slovic, 2010, for a recent overview), effectively communicating environmental risks remains a critical challenge. This article contributes to our understanding of how risk should be communicated to both the public and to policy makers, by clarifying the effect of one potential bias (outcome severity) on interpretations of verbal probability expressions. Over three studies, we focus on a range of environmental risk domains and investigate the effect of a risky outcome's severity on numerical interpretations of verbal probability expressions describing its likelihood.

Preventing dangerous climate change is perhaps the most salient of current environmental concerns, and the potential for human behavior to mitigate climate change risks increases the need for effectively communicating accurate information in this domain. The task of communicating climate change information is, however, complex, and there are many psychological barriers to engaging the public (Lorenzoni, Nicholson-Cole, & Whitmarsh, 2007), including the challenge of communicating uncertainty and risk information. Precisely this challenge is faced by the Intergovernmental Panel on Climate Change (IPCC), the body charged with producing periodic climate science assessment reports for policy makers.

Such is the level of popular interest in climate change that the assessment reports of the IPCC have been read far more broadly than most policy-oriented scientific documents. The communication challenges faced by the IPCC are nontrivial. The way that people interpret evidence about climate change is impacted by well-documented biases that influence judgments about both numerical and nonnumerical risk information (Pidgeon, Kasperson, & Slovic, 2003; Weber, 2006, 2010). At present, the IPCC communicates uncertainty through verbal probability expressions, such as "unlikely" and "likely" (e.g., IPCC, 2005, 2007; see Table 1). The terms are assigned specific numerical meanings but are typically presented in verbal format only. Budescu, Broomell, and Por (2009) reported significant discrepancies between the meanings intended by the IPCC and the numerical values that people assigned to these expressions. They also demonstrated considerable inter-person variability in the interpretation of these expressions (see also, e.g., Beyth-Marom, 1982; Brun & Teigen, 1988; Wallsten, Budescu, & Zwick, 1993).

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Table 1
Likelihood Scale of the Intergovernmental Panel on Climate Change

Terminology	Likelihood of the occurrence/outcome
Virtually certain	>99% probability of occurrence
Very likely	>90% probability
Likely	>66% probability
About as likely as not	33% to 66% probability
Unlikely	<33% probability
Very unlikely	<10% probability
Exceptionally unlikely	<1% probability

One potential reason for discrepancies between the meanings intended by the IPCC and people's interpretations of these expressions is that verbal probability expressions are typically used to communicate more information than simply the likelihood of an event's occurrence. For example, although potentially referring to the same numerical probability, affirmative expressions (e.g., "probable," "likely") direct attention to an event's occurrence, whilst negative expressions (e.g., "somewhat doubtful," "not quite certain") direct attention to an event's nonoccurrence (e.g., Teigen, 1988; Teigen & Brun, 1995, 2003; see also Juanchich, Teigen, & Villejoubert, 2010). Because they assign verbal probability expressions to events solely on the basis of their numerical probabilities (see Table 1), the IPCC is not sensitive to such subtleties. Thus, as the IPCC's use of verbal probability expressions does not conform to the pragmatics normally associated with these expressions in everyday discourse, there is potential for inconsistencies between the interpretations of these expressions and the actual risks that the IPCC intends to convey.

In addition to the pragmatics of verbal probability expressions summarized above, the characteristics of the outcomes to which verbal probability expressions refer have also been shown to influence the interpretation and communication of these expressions (Fischer & Jungermann, 1996; Patt & Dessai, 2005; Patt & Schrag, 2003; Villejoubert, Almond, & Alison, 2009; Wallsten, Fillenbaum, & Cox, 1986; Weber & Hilton, 1990). In the present article, we focus on this inter-*outcome* variability in the interpretation of verbal probability expressions—specifically, the severity of the event to which the expression refers.

The Effect of Outcome Severity on Interpretations of Verbal Probability Expressions

Patt and Schrag (2003) asked one group of participants ("recipients") to indicate the range of numerical probabilities they thought a communicator intended to convey when they described the likelihood of either a hurricane or snow flurries hitting land near Boston as "likely, perhaps very likely," or "unlikely, perhaps very unlikely." They found that the recipients interpreted such probability expressions as indicating lower numerical probabilities when they referred to the likelihood of a hurricane rather than the likelihood of snow flurries. Patt and Schrag attributed this result to the difference in the severity of the two events and concluded that increased outcome severity decreases people's numerical interpretations of verbal probability expressions. As they also observed that a group of "communicators" chose to use a higher verbal expression to convey a numerical risk of hurricanes than snow flurries, they explained the lower interpretation of the probability expressions referring to the hurricane as resulting from a shared conversational convention between communicators and recipients. Specifically, they proposed that recipients recognize that communicators assign higher probability phrases to events with serious consequences and subsequently correct for this in their interpretations. Communicators who do not recognize that verbal expressions are interpreted in this way run the risk of having recipients underestimate the probability of severe outcomes occurring. To mitigate this danger, Patt and Schrag recommended that the IPCC emphasize that its terms relate purely to the chance of the event (see Table 1) and are not influenced by event severity.

Patt and Schrag's (2003) results were, however, confounded with event base rate. Hurricanes are typically rarer than snow flurries, and it is well documented that the largest influence on interpretations of verbal probability expressions is the frequency of the event being judged (e.g., Fischer & Jungermann, 1996; Wallsten et al., 1986; Weber & Hilton, 1990). This confound makes it impossible to draw any conclusions about the effect of event severity in their study. Thus, it is unclear that simply guarding against the inappropriate use of a conversational convention (as recommended by Patt & Schrag, 2003) will result in more effective communication of climate change risks.

When the confound between event severity and base rate has been controlled, research on recipients' interpretation of verbal probability expressions has yielded mixed findings. Fischer and Jungermann (1996) reported no effect of event severity, but they dealt with the base rate/severity confound in an unusual way by providing participants with a precise numerical indication of the event's base rate. After statistically controlling for event frequency in a medical context, Weber and Hilton (1990; see also Villejoubert et al., 2009, for similar results in a forensic context) observed the opposite effect of event severity on the interpretation of verbal probability expressions, finding that expressions describing the likelihood of severe events were interpreted as representing higher numerical probabilities than those that referred to more neutral events.

Bonnefon and Villejoubert (2006) proposed that the above "severity bias" occurs because probability expressions referring to severe events are likely to be interpreted as politeness markers rather than as expressions of likelihood. In a medical context, informing a patient that they have a severe medical condition threatens the social "face" of the patient. Consequently, communicators (i.e., doctors) in this situation might be expected to use probability expressions as face-saving devices to soften the impact of bad news (on face-saving, see Brown & Levinson, 1987), rather than as genuine expressions of uncertainty. If patients believe that probability expressions are being used thus, they will adjust their estimate of the communicator's subjective probability appropriately (i.e., infer the risk is 100%, rather than "possible"). This explanation was supported in Bonnefon and Villejoubert's study, which demonstrated that the severity bias was observed only in participants who did report interpreting the expression as a politeness marker, rather than as a probability marker.

An asymmetric loss function account has also been proposed as an explanation for Weber and Hilton's (1990) findings (Weber, 1994; see also, Harris, Corner, & Hahn, 2009). On this account, people recognize the uncertainty inherent in a verbal probability expression. Given this uncertainty, it is rational to bias an estimate in the direction of the least costly error of interpretation (see e.g., Batchelor & Peel, 1998; Whiteley & Sahani, 2008, and references therein). For severe events, this correction will be in the direction of an inflated estimate of the true probability. For severe events, underestimates are associated with a costly propensity not to take suitable protective measures.

In summary, the effect of outcome severity on interpretations of verbal probability expressions remains poorly understood. The present article aims to redress this balance through three controlled studies.

Studies

Given Patt and Schrag's (2003) recommendation to the IPCC, it is essential to empirically retest their conclusion without the base rate/severity confound present. If their conclusion no longer holds, this carries implications for the IPCC's risk communication policy.

The present studies controlled for the base rate/severity confound in a novel way. Fischer and Jungermann (1996) presented participants with numerical base rates. Such a procedure provides participants with a strong anchor for their numerical probability judgments such that it is unsurprising that a manipulation of severity did not affect participants' subsequent judgments. Moreover, for many consequential real-world risks a frequentist base-rate statistic for the event is not available. For example, the climatic forecast that "future trends of increased incidence of extreme high sea level are likely" (IPCC, 2007, Table SPM.2) has no obvious base-rate statistic with which to calibrate it. Weber and Hilton's (1990) attempt to experimentally disassociate event frequency and severity failed, and they concluded "that it may be difficult to independently manipulate two variables that are negatively correlated in real life" (p. 788). In the present studies, we manipulated outcome severity by altering the *consequences* of the event being judged, rather than the nature of the event itself. In this way, event base rate is implicit but constant across experimental conditions. Studies 1 and 2 concern climate change risk, whilst Study 3 generalizes the results to risks associated with nanotechnology and nuclear power.

Study 1

Study 1 investigated how people's interpretations of verbal probability expressions referring to a potential rise in sea levels were affected by outcome severity.

Method

Participants. One hundred and one (60 female) volunteers, aged 18–75 years (*Mdn* = 35) participated in this web-based study. No incentives were provided for participation. Participants were open day visitors at the University of Warwick, as well as participants who followed an optional link in the debrief of an unrelated study.[1] Participants were randomly allocated to conditions by a JavaScript program.

Design, materials, and procedure. A 2 × 2 (Severity × Probability Expression) between-participants design was employed. The study was run online in the participant's web browser. An initial screen explained the nature of the study and required participants to indicate their sex and age and click "continue" if they consented to participate. The next two screens contained the study. Participants read one of four vignettes (their structure is shown in Table 2). The vignettes described the chance of global sea levels rising by 3 feet or more by 2015. Outcome severity was manipulated by altering the height of an island on which participants were told they lived. In the high severity condition, the island was 3 feet above sea level and would therefore disappear into the ocean if the predicted sea level rise occurred (see Table 2). In the low severity condition, participants were told that the island "is a very high island protected from the sea by 50 foot cliffs. Hence, if global sea levels rise by 3 feet, life on this island will be unaffected." Probability was manipulated by describing the likelihood as either "unlikely, perhaps very unlikely" (low probability) or "likely, perhaps very likely" (high probability). These were the same terms used in Patt and Schrag (2003). Following the vignette, participants read the following:

> Based on the forecast of the IPCC, that it is unlikely, perhaps very unlikely, that global sea levels will rise by 3 feet or more by 2015, please provide a number that you think matches the chances of this event happening.
>
> Please express your answer as a number between 0 (it is impossible) and 100 (it will definitely happen). [low probability condition]

After providing a judgment, participants were thanked and debriefed on a separate screen.

Table 2
The Vignette Used in Study 1

Global warming is melting the ice at both the north pole and the south pole. The melting of ice leads to a rise in global sea levels. The Intergovernmental Panel on Climate Change (IPCC) has issued a warning that by 2015 it is *unlikely, perhaps very unlikely*, that global sea levels will have risen by 3 feet or more. Imagine that you live on the island of Sulasemi. **Sulasemi is a very flat island that lies only 3 feet above sea level. Hence, if global sea levels rise by 3 feet, the island will disappear into the ocean.** You have been offered the chance to move to another, higher, island, and are trying to decide whether you should move.

Note. The table displays the exact text in the high severity/low probability conditions. Italics and bold formatting have been added to demonstrate the text that differs between the probability conditions (italics) and the severity conditions (bold).

Results and Discussion

The data were entered into a 2 × 2 analysis of variance (ANOVA). Aside from a significant effect of probability, $F(1, 97) = 94.08$, $p < .001$, there was a significant effect of severity, $F(1, 97) = 8.58$, $p = .004$, $\eta_p^2 = .081$, with higher numerical

[1] The unrelated study investigated hypothetical credit card repayments (using the same methodology as Stewart, 2009), and participants received 50 Maximiles points for their participation. Maximiles is an online reward scheme by which individuals can participate in surveys in order to earn reward points that they can subsequently exchange for goods and services. Fifty points can be exchanged for 50 pence's worth of goods. Please see http://www.maximiles.co.uk/ for further details.

interpretations provided in the high severity condition (see Figure 1). No interaction between severity and probability was observed ($F < 1$).

These results conflict with the conclusions of Patt and Schrag (2003) but replicate Weber and Hilton's (1990) result that probability expressions referring to severe events are interpreted as denoting higher probabilities than those referring to more neutral events.

Study 2

The primary aim of Study 2 was to replicate the effect observed in Study 1. To extend the generalizability of the result observed in Study 1, Study 2 required participants to communicate their interpretation to a third person within the scenario (as in Harris et al., 2009). This modification is of applied significance. If the same severity effect holds in this situation, its consequences are amplified, as it demonstrates the potential for risk judgments of severe events to increase with each act of communication.

Method

Participants. Eighty-three (77 female) undergraduate psychology students, aged 18–33 (*Mdn* = 19), from the University of Warwick and Cardiff University participated in the study in return for course credit.

Design, materials, and procedure. The only change from Study 1 was that participants were asked to imagine that their friend lives on the island of Sulasemi and does not have access to the report of the IPCC. In the final paragraph, participants read the following:

> Your friend has asked you to tell them the chance of global sea levels rising by 3 feet or more by 2015. Please provide your friend with an estimate that you think matches the forecast of the IPCC, that it is unlikely, perhaps very unlikely. . . . [low probability condition]

All other aspects of the method were identical to those of Study 1.

Results and Discussion

The data were analyzed as in Study 1. The expected effect of probability expression was observed, $F(1, 79) = 96.72$, $p < .001$, and again there was a significant effect of outcome severity, $F(1, 79) = 7.54$, $p = .007$, $\eta_p^2 = .087$, with expressions referring to severe outcomes interpreted as denoting higher probabilities than those referring to more neutral outcomes (see Figure 2). No interaction between severity and probability was observed ($F < 1$).

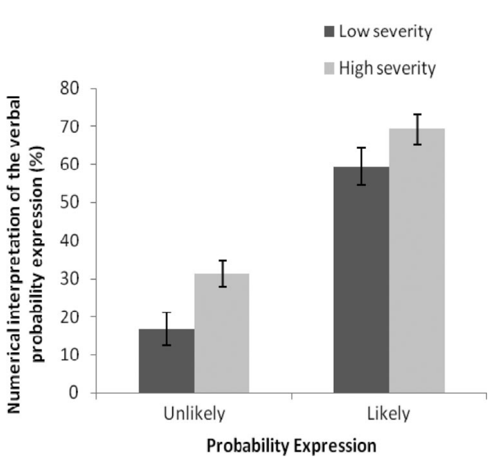

Figure 1. The effect of outcome severity on the interpretation of verbal probability expressions in Study 1. Error bars represent ±1 *SE*.

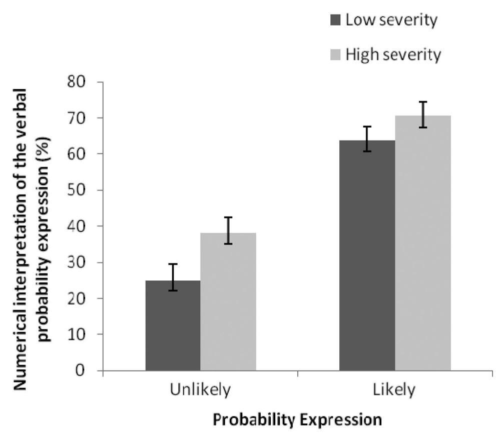

Figure 2. The effect of outcome severity on the interpretation of verbal probability expressions in Study 2. Error bars represent ±1 *SE*.

Study 3

Studies 1 and 2 provided evidence that probability expressions referring to severe outcomes are interpreted as conveying higher probabilities than those referring to more neutral outcomes. This is the first demonstration of the effect in an experimental setup that controls for event base rate empirically, using a topic of considerable applied importance. Study 3 served to extend the generalizability of the effect, demonstrated in Studies 1 and 2, through two new scenarios in the domain of environmental risk: the development of nanotechnology-based pollution sensors and the transportation of nuclear materials. These are both important and controversial risk domains. Nanotechnology is an emerging area of science about which the general public has yet to form stable attitudes (e.g., Pidgeon, Harthorn, & Satterfield, 2009–2010). The costs versus benefits of nuclear power, meanwhile, have long been debated, and it remains a controversial topic (e.g., Pidgeon, Lorenzoni, & Poortinga, 2008), sensitive to current events such as the 2011 Fukushima nuclear disaster in Japan.

Method

Participants. One hundred and sixty-three women and 28 men, aged 18–56 (*Mdn* = 19), from Cardiff University[2] participated in the study either for course credit or as volunteers.

Design, materials, and procedure. A 2 × 2 × 2 (Severity × Probability Expression × Scenario) between-participants design was employed. The study used two new scenarios in order to test

[2] The online experiment was advertised both on the experimental management system for Cardiff University psychology undergraduates and on an electronic notice board visible to all staff and students at the university. The participants were therefore a mix of staff and students, although it is assumed that the majority were students.

the generalizability of the findings across environmental risks. These scenarios concerned nanotechnology and the logistics of building nuclear power stations. Although fictional, the two scenarios were based on current environmental issues. The "nano" scenario introduced water filters that made use of nanotechnology to purify water for drinking in developing countries. Similar technology is currently being developed (e.g., Schoen et al., 2010). The "nuclear" scenario highlighted the need for alternative sources of energy (in place of fossil fuels), specifically nuclear power.

As in Studies 1 and 2, participants always judged the probability of the same event occurring: pollution sensors degrading and releasing nanoparticles into the river (nano scenario) or transporters carrying supplies for a nuclear power station being involved in a road accident (nuclear scenario). The severity of the outcome was manipulated by altering the consequences of that event. In the nano scenario, these nanoparticles were either "fatally poisonous" and would lead "to the poisoning of thousands of people," or they posed "no harm to people or the environment, as they are found naturally in a number of substances." In the nuclear scenario, the transporters' supplies were either "toxic uranium for the reactor" that, in the event of an accident, would "be released, killing thousands of people," or "drinking water for the employees" that would "be released, causing a minor traffic delay." Probability expression was manipulated as in Study 1. The scenario structures are shown in Table 3. Following the vignette, participants read the following:

> Based on the report of the risk analyst that it is unlikely, perhaps very unlikely, that [these sensors will degrade and break down over time/a road accident will occur], please provide a number that you think matches the chances of [these sensors degrading and breaking down over time/a road accident occurring].
>
> Please express your answer as a number between 0 (it is impossible) and 100 (it will definitely happen). [low probability condition]

Following an HTML consent screen, a JavaScript program randomly directed participants to one of the experimental conditions, operationalized via different SurveyMonkey surveys (http://www.surveymonkey.com). An addition in Study 3 was a manipulation check. After having provided their interpretations of the probability expressions, participants were asked the following (depending on scenario condition):

> How bad do you think it would be if [the sensors degraded and broke down over time/an accident occurred during transportation]?

Participants answered this question on an 11-point scale anchored at 0 (*not at all bad*) and 10 (*catastrophically bad*).

Participants provided demographic details at the end of the study, before being debriefed.

Results and Discussion

Manipulation check. A three-way ANOVA demonstrated that our severity manipulation was successful (see Table 4). Events in the severe condition were rated as more severe than events in the neutral condition, $F(1, 183) = 263.58$, $p < .001$. The nuclear scenario was also seen as more severe than the nano scenario, $F(1, 183) = 12.60$, $p < .001$. Importantly, however, there was no effect of probability expression, $F(1, 183) = 0.06$, $p = .81$, and the effectiveness of the severity manipulation was not qualified by any two- or three-way interactions with probability expression or scenario (all *ps* $> .13$).

Main analysis. The data were entered into a three-way ANOVA. There was a significant main effect of all three variables: probability, $F(1, 183) = 282.29$, $p < .001$; scenario, $F(1, 183) = 7.64$, $p = .006$; and severity, $F(1, 183) = 7.37$, $p = .007$, $\eta_p^2 = .04$. No two- or three-way interactions were significant. Aside from the predictable effect of probability expression, participants tended to provide higher interpretations of the expression in the nano scenario than in the nuclear scenario. Importantly, participants interpreted the probability expression as denoting a higher probability when it referred to a severe outcome rather than a neutral outcome (see Figure 3). This effect was not qualified by an interaction with either scenario, $F(1, 183) = 1.81$, $p = .18$, or expression, $F(1, 183) = 1.73$, $p = .19$. Figure 3 suggests a (non-significant) trend

Table 3
The Vignettes Used in Study 3

Nano scenario	Nuclear scenario
A new system for detecting pollutants in river water is being released onto the market. The system is based on advances in "nanotechnology." It is designed for use in developing countries, where pollutants from heavy industry often leak into rivers that are a source of drinking water. The system uses sensors to detect pollutants in water, allowing a distinction to be made between safe and unsafe water. A senior risk analyst from the Independent Risk Assessment Authority has reported that it is *unlikely, perhaps very unlikely*, that the sensors used to detect pollutants may degrade and break down over time, releasing nanoparticles into the river. **If the sensors degrade, the water will seem safe, but fatally poisonous nanoparticles released from their degradation will be present, thus leading to the poisoning of thousands of people.** An African government is seeking information to help them decide whether to install these sensors, and has asked you for your numerical estimate of the chance of the sensors degrading.	In an effort to avoid the carbon emissions of burning fossil fuels, the Swedish government is building a new generation of nuclear power stations, and **toxic uranium for the reactor** must be transported to the power stations in the North East of the country. The route currently favored for transporting the **uranium** involves driving through densely populated areas of Sweden. A senior risk analyst from the Independent Risk Assessment Authority has reported that it is *unlikely, perhaps very unlikely*, that an accident would occur in transportation. If an accident were to occur, **gallons of toxic uranium will be released, killing thousands of people.** The Swedish government is seeking information to help them decide whether this is a suitable route for the transportation and has asked you for a numerical estimate of the chance of a road accident occurring.

Note. The table displays the exact text in the high severity/low probability conditions. Italics and bold formatting have been added to demonstrate the text that differs between the probability conditions (italics) and the severity conditions (bold).

in the opposite direction to the overall pattern of results in the high probability version of the nano scenario. Given the lack of a significant interaction term, we do not wish to over-interpret this single anomaly in the results of the three studies presented.

In summary, Study 3 replicated the severity effect obtained in Studies 1 and 2, demonstrating the generalizability of the finding.

General Discussion

An understanding of interpretation biases is crucial for the effective communication of environmental risk information. Given the ubiquitous use of verbal probability expressions (as, for example, by the IPCC), we investigated inter-outcome biases in their interpretation both in a climate change context (Studies 1 and 2) and in nanotechnology and nuclear power contexts (Study 3). Our findings challenge the conclusions of Patt and Schrag (2003), who recommended that protective measures be employed by the IPCC to correct a bias that was in the opposite direction to the present results. We argue that their findings are attributable to a confound in the design of their study (namely, that their high severity event was perceived as rarer than their low severity event), as the findings are reversed when this confound is removed in the present studies.

The finding that increasing outcome severity led to higher interpretations of verbal probability expressions is in line with the results reported in Weber and Hilton (1990). It adds to the findings of Weber and Hilton by providing a factorial manipulation of outcome severity, independent of event base rate. Moreover, it seems unlikely that a forecast from the IPCC (Studies 1 and 2) or a "senior risk analyst" (Study 3) about an external, environmental event should have been interpreted as a face-saving act by our participants (Bonnefon & Villejoubert, 2006; Villejoubert et al., 2009).

Why do people interpret probability expressions as denoting higher probabilities when they refer to severe outcomes? We outline three plausible (nonexclusive) explanations for the effect. In addition to the explanations outlined below, the reader is also directed to literature investigating the role of emotions and affect generally on judgment and decision making (for overviews, see Loewenstein, Weber, Hsee, & Welch, 2001; Slovic, 2010).

Risen and Gilovich (2007) proposed an automatic process whereby negative outcomes "spring more readily to mind" than neutral outcomes, thus increasing their perceived likelihood via the established link between imagination and prediction (e.g., Carroll, 1978). The current data are also consistent with a more rational-based explanation. An "asymmetric loss function" account suggests that people's interpretations of verbal probability expressions are sensitive to asymmetries in the costs associated with over-

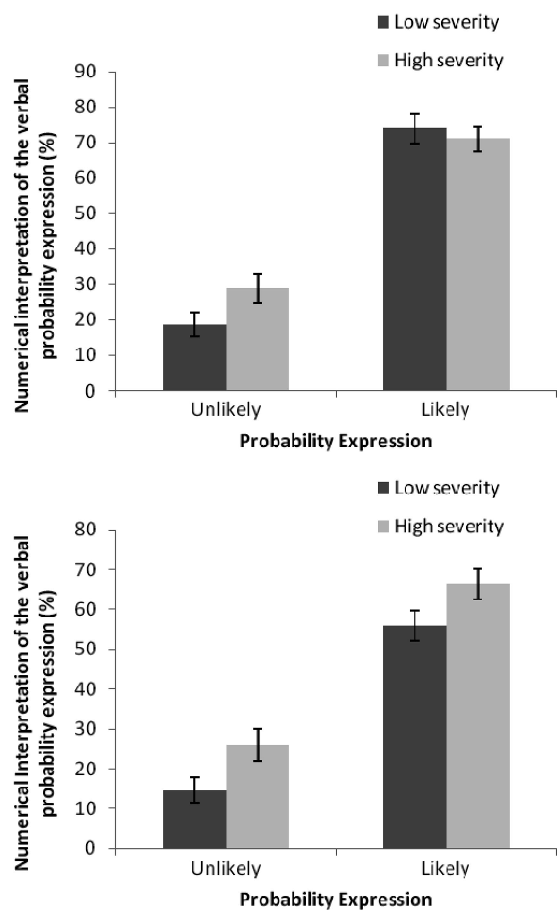

Figure 3. The effect of outcome severity on the interpretation of verbal probability expressions in the nano (top panel) and nuclear (bottom panel) scenarios in Study 3. Error bars represent ±1 *SE*.

versus underestimates of the probability to be judged (Harris et al., 2009; Weber, 1994). Finally, whilst acknowledging the potential for these so-called asymmetric loss functions to influence subjective probability judgments, Vosgerau (2010) has proposed that judgments of both positive and negative outcomes might be overestimated as the result of arousal misattribution. That is, when an outcome is positively or negatively valenced, this will induce arousal in a judge. Vosgerau presented data suggesting that this arousal might be misattributed to an outcome's likelihood of occurrence. Consequently, he proposes the probability of valenced outcomes will be overestimated relative to neutral outcomes.[3]

Future research should seek to determine the psychological underpinnings of the severity effect demonstrated in the present studies. The contribution of this article is an empirical demonstration of the precise nature of the effect, by overcoming the confounding influence of event base rate. Thus, these results clarify

Table 4
Mean Severity Ratings Given to the Potential Events in Study 3, Collapsed Across Probability Condition

Scenario	Low severity	High severity
Nano scenario	3.28 (0.30)	8.61 (0.30)
Nuclear scenario	4.78 (0.30)	9.20 (0.28)

Note. Standard errors are in parentheses.

[3] Note, however, that it is unclear how Vosgerau's theory can account for results in Lench (2009). Lench demonstrated that when affective reactions were attributed to the target event, relative likelihood judgments of positive events increased, but those of negative events *decreased*.

the effect of event severity on the interpretation of verbal probability expressions. *Ceteris paribus* (specifically, controlling for the base rate of the event), verbal probability expressions that refer to severe outcomes are interpreted as denoting higher probabilities than those that refer to more neutral outcomes. This is the first conclusive demonstration of this "severity bias" independent of the effect of base rate. In conjunction with the tendency for communicators to provide overestimates in their use of probability expressions referring to severe events (Merz, Druzdzel, & Mazur, 1991), and especially given the replication of the effect with risk *communications* in Study 2, this suggests that the subjective risk of severe outcomes related to environmental concerns (and likely in other risk domains, for example, health, technology, or finance) increases in communication.

Budescu et al. (2009) found that including numerical information with verbal probability expressions significantly improved both the inter-individual consistency of people's interpretations and their match to the interpretations intended by the IPCC (see Table 1). The present result illustrates a further problem associated with verbal probability expressions. In light of Budescu et al.'s results, we therefore reinforce their suggestion (see also Patt & Dessai, 2005) that, wherever possible, verbal probability expressions should be accompanied by numbers indicating the probability range that the words are intended to convey. For the IPCC, for example, this would entail including the probability range associated with the verbal probability expression (see Table 1) throughout their assessment reports.

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