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The interpretation of IPCC probabilistic statements around the world

David V. Budescu[1]*, Han-Hui Por[1], Stephen B. Broomell[2] and Michael Smithson[3]

The Intergovernmental Panel on Climate Change (IPCC) uses verbal descriptions of uncertainty (for example, Unlikely) to convey imprecision in its forecasts and conclusions. Previous studies showed that the American public misinterprets these probabilistic statements. We report results from a multi-national study involving 25 samples in 24 countries and 17 languages. As predicted, laypeople interpret IPCC statements as conveying probabilities closer to 50% than intended by the IPCC authors. We show that an alternative presentation format supplementing the verbal terms with numerical ranges increases the correspondence between the public's interpretations and the IPCC guidelines, and the terms are better differentiated. These qualitative patterns are remarkably stable across all samples and languages. In fact, interpretations of the terms in various languages are more similar under the new presentation format. These results suggest changing the way the IPCC communicates uncertainty.

The IPCC assembles and disseminates information about global climate change (GCC). Findings and conclusions are compiled into periodical Assessment Reports informing policymakers and the public on issues relevant to the understanding of GCC. One important issue facing the IPCC is how to communicate the uncertainties in its models and predictions. This challenge applies to all risk communications, but the debates surrounding climate change are much more intense and politicized. Questions about the reality, severity and sources of GCC and the best ways to address it frequently occur in public and political debates. Some sources of uncertainty are inherent to the climate science. Others reflect the public's imperfect understanding of climate-related issues and misperceptions about scientific consensus on the topic[1].

Probabilistic judgments can be communicated as precise numerical probabilities (for example, there is a 0.4 chance that X will occur), imprecise numerical probabilities (for example, the probability that X will occur is between 0.3 and 0.6) or probability phrases (for example, it is improbable that X will occur). The challenge facing the IPCC is to convey information with the level of precision warranted by the available evidence[2]. Using precise (numerical) probabilities could be misleading, as it would imply too high a level of precision, and of the consensus among experts. In recent assessments the IPCC has used verbal descriptions of uncertainty such as Likely accompanied by a translation table reproduced in Table 1 (ref. 3). Recent empirical work[4,5] has questioned the efficiency of this method and has documented the superiority of an alternative dual-scale combining probability phrases and numerical ranges.

We report results of an international study designed to document and compare the efficiency of this method of uncertainty communication in various countries and languages. We also explore the relationship between this efficiency and the perceptions of, and beliefs about, GCC.

Communication of uncertainty by probability phrases

Psychologists have documented large individual differences in the ways people understand, communicate and use probability phrases[6,7]. They found that representations and interpretations of probability terms are context dependent[8–10]; recipients of verbal forecasts interpret them as less extreme and more imprecise than intended by the communicators[11,12]; most people prefer to communicate their opinions verbally, but prefer receiving precise numerical information[13,14]; probability terms are susceptible to self-serving interpretations[15]; and verbal lexicons vary markedly across individuals[16–18], as does the interpretation of most verbal terms[19–21].

These results induce an illusion of communication that stems from the (intuitive, but false) assumption that everyone interprets terms similarly across contexts and circumstances. Some researchers[22,23] have suggested using standardized lists of terms accompanied by numerical ranges to reduce errors in communicating uncertainty. However, it is difficult to 'legislate' language. For example, National Weather Service weather forecasters, trained to use a set of phrases in meteorological forecasts, reverted to the colloquial meaning of the same phrases when they were embedded in different contexts[9].

Nevertheless, this is the solution that the IPCC adopted. Authors are instructed to use a scale employing 7 verbal terms to convey uncertainties (Table 1). Even if all authors comply with these instructions, it is important to test whether the readers of the reports understand these terms as intended by the authors. This is a serious concern because critics use uncertainty as an excuse to dismiss the findings all together.

Participants in previous studies[4,5] read sentences containing probabilistic terms extracted from IPCC reports, and judged the probabilities intended by the authors. The consistency between readers and authors, as measured by the degree to which the participants' judgments matched the conversion table, was low. Responses were highly regressive—underestimating high probabilities, and overestimating low values—and the variability in readers' interpretations far exceeded the uncertainty implied by the IPCC terms. A reanalysis of these data[24] found that negatively worded phrases caused responses to be more regressive and more varied than their positively worded counterparts. Furthermore, the interpretation of the phrases was correlated with the respondents' beliefs in, and experience with, GCC, their education, numeracy and ideology.

[1]Department of Psychology, Fordham University, 441 East Fordham Road, Bronx, New York 10458, USA, [2]Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, Pennsylvania, 15213, USA, [3]Research School of Psychology, Bldg 39, The Australian National University, Canberra A.C.T. 0200, Australia. *e-mail: budescu@fordham.edu

Table 1 | IPCC guidelines for translation of probability phrases.

Phrase	Likelihood
Virtually certain	>99%
Very likely	>90%
Likely	>66%
About as likely as not	33%–66%
Unlikely	<33%
Very unlikely	<10%
Exceptionally unlikely	<1%

Note: In some IPCC reports authors have used the phrases 'More likely than not' for probabilities > 50%, 'Extremely likely' for probabilities above 95% and 'Extremely unlikely' for probabilities below 5%.

Remarkably, the addition of numerical ranges to the verbal probabilistic terms in each statement[4,5] was effective in increasing consistency with the intended meanings, suggesting that the effectiveness of the uncertainty communication in the IPCC reports can be improved significantly by replacing the present reporting method with a dual scale using verbal terms and numerical values. The independent review of the IPCC (ref. 27) endorses many recommendations in these papers.

The present study

Climate change is a global problem and the IPCC issues its reports in all UN official languages and reports are translated into many other languages (http://www.ipcc.ch/publications_and_data/publications_and_data.htm). We seek to determine whether the method used by the IPCC to communicate uncertainty (verbal terms with the translation table in an appendix) resonates identically in all countries and languages. Are risks, estimates and forecasts listed in the reports interpreted as more, or less, severe and as more, or less, uncertain in various countries, simply because of the use of probability phrases? To this end, we conducted a large-scale multi-national study. We focus on four verbal terms used in the IPCC reports, and address the following questions. Are probabilistic pronouncements of the IPCC reports interpreted similarly everywhere? Can the alternative Verbal–Numerical (VN) scale improve the effectiveness of communication? Are any cross-national differences in the interpretations of the verbal assessments related to the overall level of belief in, and attitudes to, GCC in these countries?

Interpreting uncertainty terms in IPCC reports

Figure 1 shows the distribution of estimates of the IPCC terms—Very unlikely, Unlikely, Likely and Very likely—averaged across items using the same term across all 25 samples, separately for each condition. For each term we show the central 90% of the distribution, with the box covering the central 50%, and mark the median and the mean. The plot also includes horizontal lines at thresholds suggested by the IPCC guidelines. The distributions are too regressive (closer to 50% than the IPCC prescriptions) but the distributions are more extreme under the VN presentation. Consequently, the terms are better differentiated under the dual format as shown in Supplementary Fig. 1.1 in Appendix 1. These results are replicated in all 25 samples (Supplementary Table 1.1 in Appendix 1).

Judges provided lower and upper bounds for each term, which define judged ranges. We calculated what percentage of the judges' range overlaps the prescribed range of the same term (ranging from 0 if completely outside the IPCC prescription to 100% if fully embedded in it). The mean overlap is 33.6% for VN but only 18.5% for the Translation condition. The differences hold in all samples, but are most pronounced for the extreme terms (Very unlikely and Very likely).

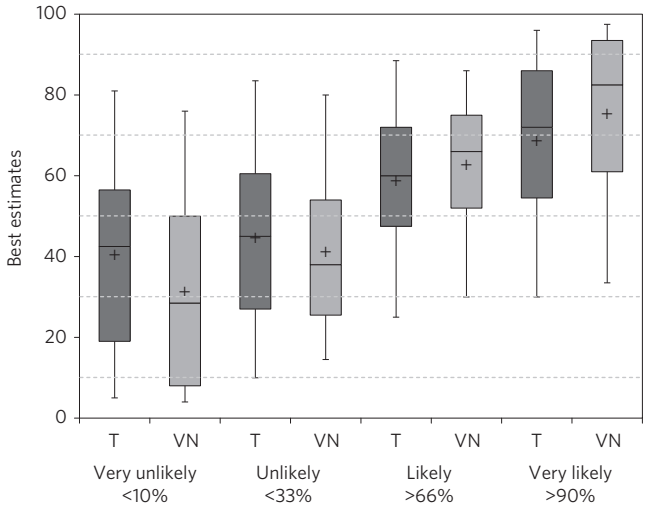

Figure 1 | Distribution of the best probability estimates of the 4 terms by condition across 25 samples. For each term we show the central 90% of the distributions, with the box covering the central 50%, the horizontal line marking the median and the plus symbol marking the mean. The dashed horizontal lines mark the IPCC guidelines. T, Translation; VN, Verbal–Numerical.

Consistency with IPCC guidelines

We counted for every respondent the number of estimates, out of the 8, that were consistent with IPCC guidelines. Figure 2 shows the cumulative distribution of these counts in both conditions across all 25 samples. The distribution in the VN condition stochastically dominates (for every proportion there are more judges with higher levels of consistency under the VN condition) the one from the Translation (mean consistency of 40% versus 27%). This pattern holds for all terms, but the effect is more pronounced for Very unlikely and Very likely (Fig. 1.2, in Appendix 1). Figure 3 shows that consistency with the IPCC guidelines improves under the VN presentation mode in all samples. The overall proportional reduction in error (PRE = (VN compliance−Translation compliance)/(100% −Translation compliance) ranges from 7% (Korea) to 29% (Israel) with an overall mean of 17% (Supplementary Fig. 1.4 in Appendix 1).

Agreement across samples

Moving beyond the differences between the two conditions, we turn to agreement between samples exposed to the same terms in different languages. Let F_{w_i} and F_{w_j} be the distribution of numerical estimates for any two terms, W_i and W_j, and define the overlap between the two distributions: $O_{ij} = 1 - \sum_{p=0}^{100} |F_{pw_i} - F_{pw_j}|/2$. This measure ranges from 0 (when the distributions do not overlap) to 1 (when the distributions coincide). We calculated overlap measures between the terms in all of the samples, and performed non-metric multidimensional scaling analysis. The two panels in Fig. 4 present solutions for the two conditions. Each plot includes 100 points (4 terms × 25 samples), and the closer two points are, the higher the overlap between their distributions. Both solutions show four clusters—one for each term. One dimension distinguishes the high/positive terms and the low/negative ones, and the other differentiates between the central and extreme terms. To highlight this pattern countries' names are omitted (individual countries' coordinates are presented in Supplementary Table 1.2 in Appendix 1).

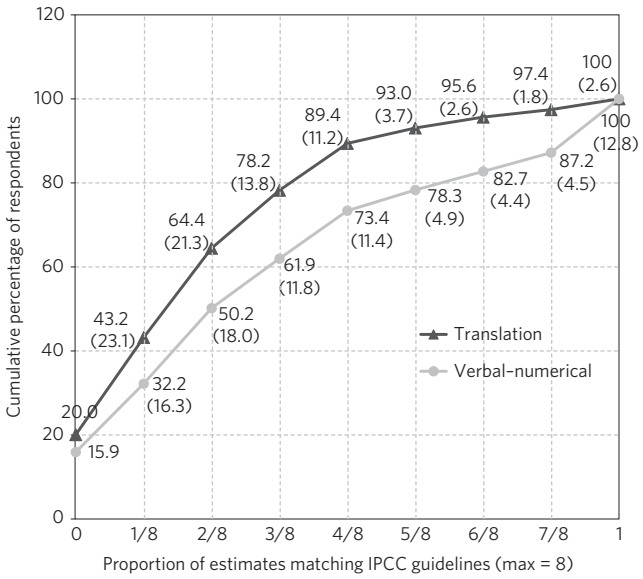

Figure 2 | Cumulative distributions of rates of consistency with IPCC guidelines under the two conditions, across all 25 samples. The numbers in parentheses indicate the proportion of judges at each point.

The clusters in the VN presentation are tighter and better differentiated, so we observe much greater cross-samples homogeneity in the interpretation of the terms. The solution based on the VN condition has smaller within-cluster distances (217 versus 225) and larger between-cluster distances (1,892 versus 1,337), so the between/within ratio is considerably higher (8.72 versus 5.94).

Effects of beliefs and attitudes to climate change

We correlated the level of consistency with IPCC guidelines in each sample with mean responses to the various questionnaires administered in that country. The level of consistency with the guidelines is higher, on average, in countries where respondents reported higher pro-environmental attitudes and higher levels of belief in, and concern about consequences of, GCC in both presentation modes. We will present these results in more detail in future papers. Importantly, no measure was significantly correlated with any measure of improvement in consistency under the VN presentation (Supplementary Table 1.3 in Appendix 1). Thus, the benefits of the improved presentation mode are, essentially, uniform across samples and languages.

Implications for the IPCC

In all samples, people interpreted the probabilistic pronouncements of the IPCC regressively, suggesting that they would underestimate (overestimate) the high (low) probabilities that the reports seek to communicate. What is the source of this excessive and, to some, surprising level of departure from the prescribed values? This pattern is, most likely, due to a combination of cognitive factors such as the vagueness and elasticity of language and the tendency of listeners to qualify and discount information provided by communicators, and motivated reasoning driven by preconceptions

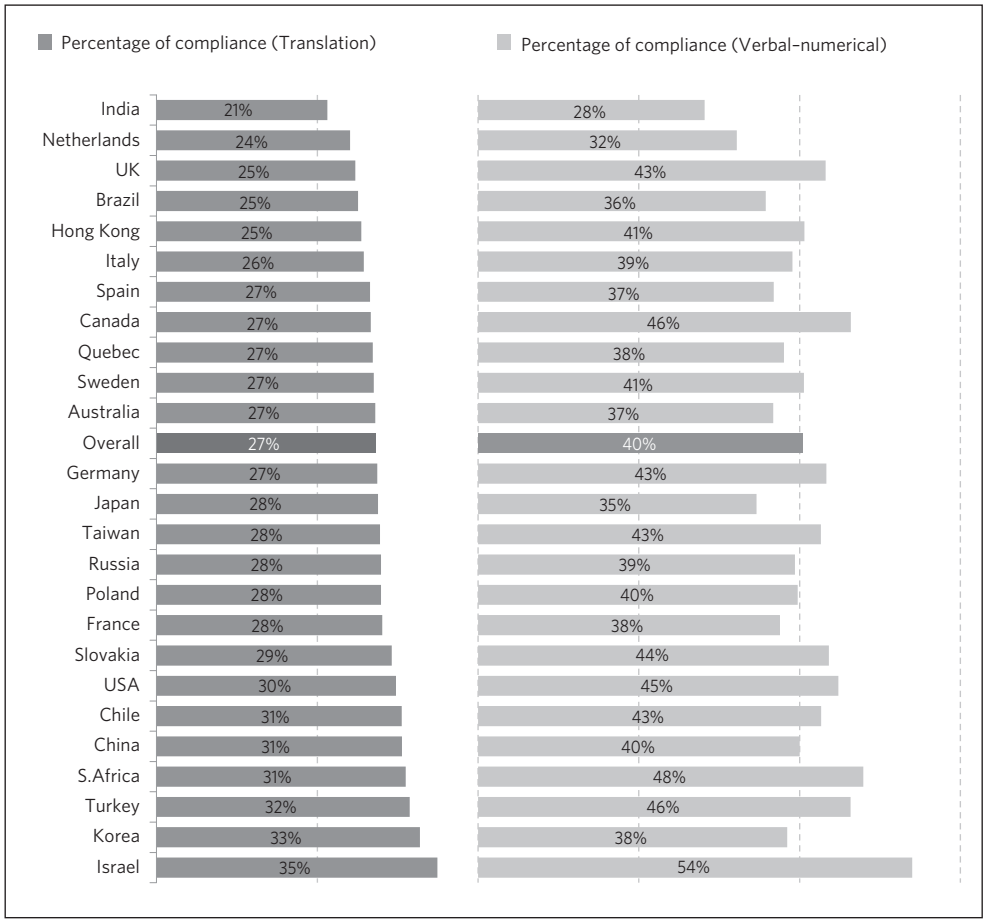

Figure 3 | Consistency rates with IPCC guidelines in the two conditions, by sample. Samples are ordered by consistency rate in the Translation condition.

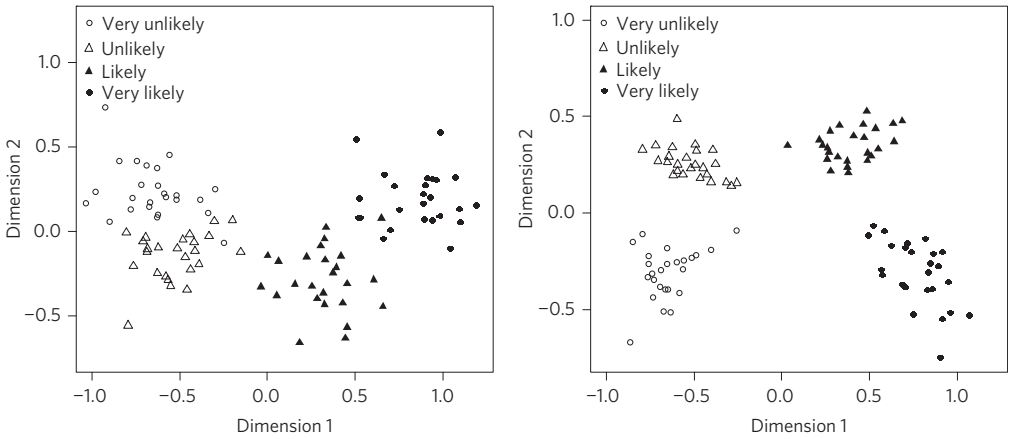

Figure 4 | The two-dimensional representation of the 4 target terms in the 25 samples in the Translation condition (stress = 0.009; left panel) and the VN condition (stress = 0.006; right panel). See coordinates in Supplementary Appendix 1.

about the subject matter[6]. Next, we use auxiliary results in our survey—judgments of the same terms by the same respondents in the absence of any context—to highlight some explanations, and consider their implications for the IPCC.

It is possible that the guidelines seem 'artificial' and are incompatible with people's 'natural' interpretation of the terms. There is some plausibility to this assertion: the median lower and upper judged bounds (out of context) of the target terms are less extreme than the values in the translation table: 9% ≤ Very unlikely ≤ 30%; 13% ≤ Unlikely ≤ 39%; 46% ≤ Likely ≤ 74%; 51% ≤ Very likely ≤ 86%. This can account for part of the regressive pattern, especially for the two extreme terms, and also explains why the VN presentation is especially effective in these cases. This result highlights the need to rethink the choice of terms and, more importantly, choose the bounds in the translation table on the basis of hard data.

Another possible explanation is that judges regress towards 50% to 'signal' that they do not know much about climate change, as responses to the knowledge items in our, and other surveys[33] indicate. We compared for each person the mean absolute deviation (MAD) from 50% across all four terms, in the absence of context, and for the IPCC items. When asked to quantify the terms in the absence of a specific context, the average MAD is 24.1 (23.7 in the Translation group and 24.6 in the VN group). In the Translation group, it is significantly lower (MAD = 20.2) when answering IPCC items, and 61% of the judges are more regressive in their interpretation of the same terms in the context of climate change. This pattern is significantly attenuated, in the VN group, where MAD = 23.0. Only 54% of the judges in this group are more regressive when answering IPCC items, and in 7 of the 25 samples, this pattern is actually reversed. Thus, another benefit of the VN format is that it mitigates the tendency to revert to the ignorance prior.

To conclude, the proposed method—presenting the verbal term and its corresponding numerical range—is highly effective and beneficial: the interpretations of the terms were more extreme and judges differentiated better between them; the range of values people associate with the various terms was reduced; and the level of agreement with IPCC guidelines increased significantly. Remarkably, these results were observed in all samples, regardless of their mean views of, levels of belief in, and experience with GCC. In fact, the VN format reduced inter-sample variability in interpretation, and the meaning of terms in various languages is more uniform.

These results make a compelling argument that to improve its communication, the IPCC should recalibrate the bounds defining their terms and adopt the dual VN format. Although our focus has been on how readers interpret the report, this change would also remind the authors of the intended meaning of the terms and maximize their level of adherence to the guidelines.

Methods

Instruments. The survey contained the following components. (1) Sentences with probability phrases: participants judged 8 sentences from IPCC reports (listed in Supplementary Appendix 2) in their native language. We used two sentences containing each of the four target terms: Very unlikely, Unlikely, Likely and Very likely. For each sentence the respondents provided their best estimate and estimates of the lower and upper bounds of the report's intended meaning. (2) Experience with, and perceptions of, global warming: a questionnaire probing the respondents' experiences with, perceptions of, and attitudes to global warming (Supplementary Appendix 2) including subscales measuring belief in global warming, personal experience of global warming, perceived causes of global warming, perceived consequences of global warming and belief in free market system[5,28]. (3) Attitudes to environment: two scales measuring environmental worldview[29,30]. (4) Knowledge about global warming: two scales measuring endorsement of real and bogus causes of global warming[31]. (5) For intentions to act: three scales measuring endorsement of mitigation actions and the belief in self-efficacy[28,31]. (6) Numeracy: a scale consisting of 5 questions from ref. 32. (7) Context-free probability phrases: the participants were asked to provide the best numerical translation and range (lower and upper bounds) for each of the 4 target terms in everyday language (with no specific context). (8) For demographic information: age, sex, education, ethnicity, political affiliation, and income.

Translation. The English forms of all these questionnaires were translated (and back translated for validation) to the various languages by the local coordinator. Official translations of the IPCC items were adopted if available.

Participants. We administered the survey to 27 samples in 25 countries in 18 languages. We sampled adults (18 years or older) and the targeted sample size was 400 in every country. A total of 13,014 people completed the survey (recruited through Survey Sampling International, recruitment and compensation tailored to individual countries). After eliminating participants who completed the survey in less than 8 min; answered less than 50% of the questions, and answered identically (straight lining) questions on several pages, we retained a sample of 10,792 valid responses. The median duration of administration was 19 min. Supplementary Appendix 3 presents key demographic information for the various samples. The two Arabic-speaking samples (Egypt and Israel) were considerably younger and male dominated than the other samples, so they are excluded from the main analyses based on 25 samples and 10,239 respondents. This exclusion does not affect any of the key results as the same patterns were observed in these samples as well (Supplementary Table 1.1. in Appendix 1).

Experimental design. Participants in each country were randomly assigned to one of two groups: Translation and Verbal–Numerical (VN). The difference between them was the way probability phrases were presented. The Translation group saw the IPCC items as they appear in the text of the report. The translation table was described in the instructions and accessible throughout the study (Supplementary Appendix 4). On average subjects in the Translation condition clicked to show the IPCC guidelines 14% (about 1 out of 8 items) of

the time. The rate was quite uniform across countries (between 10 and 20%) with two exceptions: Taiwan 25% at one end, and Korea 5% at the other.

The VN group saw the numerical ranges from Table 1 attached to each phrase. For example, in the sentence 'It is very likely that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent' the probability phrase was presented as 'Very likely (>90%)' in the VN group.

The order of components was randomized within each group according to the following scheme: half of the participants started with IPCC items followed by the questionnaires about experiences, attitudes and knowledge; the other half started with these questionnaires followed by IPCC items. The numeracy scale, the context-free judgments of the probability phrases and demographics were administered at the end of the surveys in both groups.

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Author contributions

D.V.B.: initiated project, design, data analysis, and lead writer of the paper. H-H.P.: Coordinated data collection, design, data analysis, and writing. S.B.B.: Design, data analysis, and writing. M.S.: Data analysis and writing.

Additional information

Supplementary information is available in the online version of the paper. Reprints and permissions information is available online at www.nature.com/reprints. Correspondence and requests for materials should be addressed to D.V.B.

Competing financial interests

The authors declare no competing financial interests.