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Context affects the interpretation of low but not high numerical probabilities: A hypothesis testing account of subjective probability

Baler Bilgin [a,*], Lyle Brenner [b]

[a] College of Administrative Sciences and Economics, Koç University, Istanbul 34450, Turkey
[b] Warrington College of Business Administration, University of Florida, FL 32611-7155, United States

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ABSTRACT

Low numerical probabilities tend to be directionally ambiguous, meaning they can be interpreted either positively, suggesting the occurrence of the target event, or negatively, suggesting its non-occurrence. High numerical probabilities, however, are typically interpreted positively. We argue that the greater directional ambiguity of low numerical probabilities may make them more susceptible than high probabilities to contextual influences. Results from five experiments supported this premise, with perceived base rate affecting the interpretation of an event's numerical posterior probability more when it was low than high. The effect is consistent with a confirmatory hypothesis testing process, with the relevant perceived base rate suggesting the directional hypothesis which people then test in a confirmatory manner.

Introduction

Imagine that you are planning a short trip to Phoenix and that the weather forecast for the day of your visit specifies a 30% chance of rain. How likely will you be to bring your umbrella with you on this trip? Now imagine instead that the city you are planning to visit is Seattle, with the same forecasted 30% chance of rain. Will you be more likely to take your umbrella with you to usually-rainy Seattle than to usually-dry Phoenix, despite the equal forecasted chances of rain for your visit? The same probabilistic forecast may be interpreted differently, depending on context. Indeed, contextual factors have been shown to influence the interpretation of not only vague verbal probability phrases such as "likely" (Wallsten, Fillenbaum, & Cox, 1986), but also precise numerical probabilities (Teigen & Brun, 1999; Windschitl & Weber, 1999). For example, a 30% chance of rain could be interpreted as subjectively more likely when the forecast is for London than when it is for Madrid (Windschitl & Weber, 1999).

Now imagine instead that the forecasted chances of rain in the two cities are both 70% rather than 30%. Will you still be more likely to bring your umbrella to Seattle than to Phoenix? Will the perceived base rate of rain in Phoenix or Seattle color the interpretation of a 30% chance of rain differently than the interpretation of a 70% chance of rain? More broadly, will contextual factors differentially affect the interpretation of precise numerical estimates of different magnitudes? In this paper, we show that perceived base rates can affect the interpretation of small posterior probabilities (e.g., 30% chance of rain) to a greater extent than large (e.g., 70% chance of rain) posterior probabilities. This novel interaction is predicted to arise because although low numerical probabilities are precise with respect to their location on the probability scale, they are more *directionally ambiguous* than high numerical probabilities. That is, low probabilities can be more flexibly interpreted as either positive (e.g., occurrence of rain) or negative (e.g., nonoccurrence of rain) statements about the focal hypothesis, whereas large numerical probabilities are typically taken as positive statements (Teigen & Brun, 1995). Accordingly, the greater directional flexibility of low numerical probabilities may allow contextual factors to play a larger role in their interpretation.

Consistent with this reasoning, our findings reveal an assimilative effect of context on the subjective probability of low but not high numerical probabilities: a 30%, but not a 70%, chance of rain seems more likely when the forecast is for Seattle than when it is for Phoenix. The full pattern of data suggests that a hypothesis testing process underlies the impact of context on the interpretation of directionally ambiguous numerical probabilities. That is, perceived base rate appears to influence, associatively, the perceived direction of the focal hypothesis (i.e., positive vs. negative). This directional hypothesis is then tested in a confirmatory manner, such that positively-represented hypotheses tend to

* Corresponding author. Address: Department of Marketing, Koç University, Istanbul 34450, Turkey. Fax: +90 212 338 1393.

E-mail addresses: babilgin@ku.edu.tr (B. Bilgin), lyle.brenner@warrington.ufl.edu (L. Brenner).

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recruit evidence that the event will occur, and negatively-represented hypotheses tend to recruit evidence that the event will not occur.

The current theoretical framework integrates prior work on perceived directionality of numerical probabilities (Teigen & Brun, 1995) with work on the impact of context on the subjective probability of numerical probabilities (Windschitl & Weber, 1999) to argue that the impact of context on subjective probability is more pronounced for small than large numerical probabilities. Furthermore, while previous work has studied how objective probabilities may be represented together with a subjective sense of their likelihood (Windschitl & Weber, 1999), the current paper examines how a subjective sense of likelihood may be generated in the first place by studying hypothesis testing as a potential mechanism. We also reconcile our findings with prior research that showed a contrast effect of prior expectations on perceived directionality (Teigen & Brun, 2000). Finally, the results show that in some cases perceived base rates may be used to interpret posterior probabilities. Although the normative status of this finding may be debatable, it nevertheless stands in contrast to much prior work showing neglect of base rates. A debiasing technique is proposed to reduce the potentially inappropriate use of base rates in interpreting posterior probabilities.

Directional ambiguity of numerical probabilities

Much research on the interpretation of probabilistic statements has focused on verbal probability phrases (Budescu & Wallsten, 1987; Wallsten et al., 1986). Because verbal probability phrases have a range of plausible interpretations, contextual factors such as base rate information affect which interpretation will be used (Wallsten et al., 1986; Weber, 1994; Weber & Hilton, 1990). For example, Wallsten et al. (1986) showed that the verbal forecast of "likely" was assigned a higher numerical probability when it referred to snow in December (a high base-rate event) than in October (a low base-rate event).

In contrast to verbal probabilities, numerical probabilities appear very precise and therefore would seem to be "less susceptible to undesirable individual difference and context effects" (Weber & Hilton, 1990, p. 789). The apparent precision of numerical probabilities does not necessarily mean that their interpretation is unambiguous, however. In particular, numerical probabilities can be *directionally ambiguous*. A 30% chance of rain, for example, can be meaningfully taken to refer to either the occurrence or the non-occurrence of rain. That is, one may interpret 30% chances of rain positively and focus on the fact that rain is possible; that the probability of rain is greater than 0%. A negative interpretation, on the other hand, would focus attention on the fact that it may *not* rain, which stresses that the probability of rain is much lower than 100%. In this sense, the precision of numerical probabilities does not necessarily inform which end of the probability scale should guide the interpretation of the focal event. Because interpretation of probabilities may be influenced not only by their numerical precision, but also by their directional ambiguity (Teigen & Brun, 1995), numerical probabilities may be subject to more flexible interpretation than it may initially seem.

To better illustrate the directional ambiguity of a numerical probability, consider the sentence-completion task that Teigen and Brun (1995) used to determine the perceived directionality of a numerical probability. Participants were asked to complete statements such as "There is a 25% probability that arson was the cause of the fire, because...." If the participant completed the sentence with a description suggesting arson, then this was considered a positive interpretation of the numerical probability. If, on the other hand, the participant generated reasons why arson was *not* the cause of the fire, this was considered a negative interpretation of the very same numerical probability. Documenting the directionally ambiguous nature of numerical probabilities, Teigen and Brun (1995, experiment 1) showed that numerical probabilities led to more variety than verbal probabilities in the type of positive and negative reasons judges offer to explain an uncertain event.

Existing research suggests some contextual factors that might affect the interpretation of precise numerical probabilities. For example, Svenson (1975) found that the valences of the events in question affected the interpretation of their numerical probabilities (also see Becker & Sarin, 1987). More recently, Windschitl and Weber (1999) showed that the interpretation of numerical probabilities is affected by the perceived representativeness of the event for a given context. For example, the same 20% chance of a specific individual with an ailment contracting a disease was taken as more likely when visiting India (where the disease was perceived as relatively common overall) than Hawaii. Results suggested that this effect arose because participants thought of the disease as more representative of India than Hawaii.

Greater directional ambiguity of small numerical probabilities

Some numerical probabilities may be more directionally ambiguous than others. Using the sentence-completion task described above, Teigen and Brun (1995) also showed that low numerical probabilities are more directionally ambiguous than high numerical probabilities. Specifically, judges generated a mixture of positive and negative reasons when completing sentences involving low probabilities (e.g., 10%, 25%), but tended to interpret large numerical probabilities almost exclusively positively.

Because judges tend to interpret large numerical probabilities almost exclusively positively, with little or no directional ambiguity, we propose that contextual factors such as perceived base rates are unlikely to influence the interpretation of large numerical probabilities. That is, a given posterior probability of 70% chance of rain should be interpreted positively regardless of whether the rain forecast is for Seattle or Phoenix. However, because small numerical probabilities can be interpreted positively or negatively, perceived base rates should be more likely to suggest a particular direction for interpretation. This contention is broadly consistent with much research showing that ambiguity accentuates the impact of contextual factors on information processing and judgment (e.g., Binder & Morris, 1995).

Several factors may contribute to the greater directional ambiguity of low numerical probabilities. It may be a manifestation of a positivity bias, for example, with judges having a tendency to interpret a probability positively whenever possible (Peeters & Czapinski, 1990). Another reason may be judges' tendency to process information in the frame provided by the context, as suggested by Teigen and Brun (2000). That is, because probability statements typically refer to the occurrence rather than non-occurrence of the target event (e.g., 20% *probability* of rain), judges may generate reasons cued by the occurrence frame, leading to the generation of positive reasons even for low numerical probabilities. The fact that the target event is rain suggests a possible positive interpretation (it could rain), but the fact that the number preceding the event is low suggests a possible negative interpretation (it probably will not rain). Although there are likely other reasons for the greater directional ambiguity of low numerical probabilities, we do not examine them in the current experiments. We simply build on the Teigen and Brun (1995) finding about the greater directional ambiguity of low probabilities and test its implications for the effect of perceived base rate on assessments of posterior probabilities.

Although prior work examined the impact of context on subjective probability, it has not directly examined the role of probability magnitude as a moderating factor; contextual factors have been assumed to have the same impact on subjective probability across different values of uncertainty. For example, Windschitl and Weber (1999) examined the effect of representativeness on the interpretation of numerical probabilities using scenarios that employed almost exclusively low base rate probabilities. Specifically, 42 of the 49 different scenarios they used employed relatively low numerical probabilities (below 60%). Hence, the main effect of representativeness in their experiments is consistent with the current conceptualization because directionally ambiguous low numerical probabilities should be susceptible to the influence of a contextual factor such as representativeness. But if directional ambiguity is critical for contextual effects, as we propose, then it may be inappropriate to generalize the observed effect of context across the entire probability range.

In sum, we predict a greater impact of perceived base rate of an event on its subjective probability when the given numerical forecast is low, and is thus directionally ambiguous. When the given numerical forecast is high and thus less directionally ambiguous, on the other hand, there should be little effect of perceived base rate on its interpretation. If true, then the next question becomes how perceived base rate may affect the interpretation of directionally ambiguous numerical probabilities. We propose that a confirmatory hypothesis testing process may drive this effect, with perceived base rate determining the direction of interpretation for the directionally ambiguous numerical probability.

Confirmatory hypothesis testing

Hypothesis testing has been shown to underlie many diverse phenomena, including social comparison (Mussweiler, 2001), anchoring (Chapman & Johnson, 1999), and probability estimation (Sanbonmatsu, Posavac, & Stasney, 1997). Hypothesis testing is often confirmatory in nature, with judges recruiting and interpreting evidence consistent with the focal hypothesis that is tested. Sanbonmatsu et al. (1997) showed, for example, that people may overestimate the probability of a focal hypothesis because they may selectively seek evidence for the occurrence of the focal outcome at the expense of non-focal outcomes. Teigen and Brun (1999) proposed that the selection of a particular hypothesis may be partly determined by the directionality implied by a relevant verbal probability phrase. For example, when asked how *probable* it is that the butler was the murderer, people test the "positive" hypothesis that the butler was the murderer because *probable* is a positively directed phrase. As a result, they underweight evidence inconsistent with this hypothesis, leading to an overestimation of the probability of the "positive" focal hypothesis. When the question becomes how *improbable* it is that the butler is the murderer, a verbal phrase that is negatively directed, people selectively test the "negative" hypothesis and generate reasons why he is not the murderer, leading to a relative overestimation of the probability of the "negative" focal hypothesis.

Teigen and Brun's (1999) argument applied to verbal probability phrases that inherently suggest a particular direction. Factors that may determine the focal hypothesis when interpreting directionally ambiguous numerical probabilities remain unexplored, however. We propose that in such situations, contextual cues will influence the direction of the focal hypothesis. Base rate probability is one such cue, especially in situations that render it highly salient or accessible in memory. It is hypothesized that the highly accessible base rate probability of a target event may determine the direction of the focal hypothesis (i.e., positive or negative) when the event's given numerical probability is directionally ambiguous. In turn, this will affect the direction of reasons generated and the subjective probability of the target event. This prediction is consistent with prior research suggesting that the focal hypothesis judges test is typically cued by the decision making context (Sanbonmatsu, Posavac, Kardes, & Mantel, 1998).

The base rate probability manipulation in our scenarios implied either a positive or a negative focal hypothesis: whether or not it will rain on a specific day in the target city (experiments 1, 3, and 4), or whether or not a specific person will contract malaria in the target city (experiment 2). Prior research showed that recent or chronic accessibility of a hypothesis may make it focal due to its privileged retrieval from memory (see Sanbonmatsu et al., 1998). Hence, given a directionally ambiguous numerical forecast for Seattle, people should be more likely to naturally consider and test the hypothesis that it *will rain*, owing to the strong association of rain with Seattle. To the extent that one can readily recruit evidence for the focal hypothesis of "rain" in Seattle, the subjective probability of rain in Seattle should increase. Similarly, people should be more likely to naturally consider and test the hypothesis of *no rain*, owing to the strong association of dryness with Phoenix, when faced with a directionally ambiguous forecast for this city. This should in turn reduce the subjective probability of rain in Phoenix.

Existing research provides further support for our expectation of an assimilative effect of perceived base rate on the interpretation of numerical posterior probabilities. For example, social judgment research showed that the interpretation of an ambiguous behavior depends on the construct most accessible at the time of judgment (Higgins, Rholes, & Jones, 1977). When judges use the accessible construct to interpret the ambiguous behavior, judgments about the ambiguous behavior are shown to tend toward the activated construct (i.e., assimilation effect). One can also view this process as involving a comparison between a standard that the base rate probability suggests and the day for which a rain forecast is provided, and test for either why that specific day may be similar to or dissimilar from that standard (Mussweiler, 2001; Windschitl & Wells, 1998). Prior research shows that such comparisons typically involve an initial focus on similarities (Gentner & Markman, 1997; Tversky, 1977), making similarity testing the default option (Chapman & Johnson, 1999; Mussweiler, 2001). Hence, judges should be more likely to consider why a day with a 30% chance of rain should be similar to the "rain" ["dryness"] standard implied by the perceived base rate probability of rain in Seattle [Phoenix], and to recruit evidence confirming this similarity, suggesting an assimilative effect of perceived base rates.

Overview of the experiments

The current experiments provided participants with precise posterior numerical probabilities, customized for a particular circumstance, such as the weather forecast for a particular city on a particular day. Participants then expressed their sense of likelihood for the target event. Prior research showed that people represent objective probabilities together with a subjective sense of their likelihood (Windschitl & Weber, 1999), which influences subsequent judgments. To tap into participants' subjective sense of likelihood in the presence of a provided numeric probability, the experiments asked participants either to directly assess the subjective probability of the target event on a verbal probability scale (experiment 2), or to rate their likelihood of engaging in a behavior that depends on the subjective probability of the target event (i.e., bringing an umbrella given the rain forecast, experiments 1, 3, and 4).

In order to manipulate perceived base rates, in experiments 1, 3, and 4, we used two cities that are widely known to differ in their base rate probability of rain, Seattle and Phoenix. A criterion in selecting these destinations was their strong association in memory with the target event of rain (i.e., rain and Seattle; dryness and Phoenix) among our US undergraduate participants. In experiment 2, perceived base rates were manipulated using two cities, Calcutta and Honolulu, which were assumed to differ in the perceived prevalence of malaria in line with prior research (Windschitl & Weber, 1999). In all experiments, participants encountered a posterior probability of the target event (e.g., forecasted chance of rain) in either the high or low base rate city, depending on the condition, and judged its subjective probability.

Experiments 1a and 1b

Experiment 1a tests the basic prediction that the perceived base rate probability of rain affects the interpretation of a given precise numerical forecast of rain more when the numerical forecast indicates a low rather than a high chance of rain.

Method

Participants and design

One hundred sixty-six undergraduate students, participating for class credit, were randomly assigned to one cell of a 2 (base rate of rain: high/Seattle vs. low/Phoenix) x 2 (magnitude of weather forecast: 30% vs. 70%) between-subjects design.

Procedure

Participants saw the following scenario on a computer.

> "Imagine that you are going to Seattle, WA [Phoenix, AZ] for a two-day visit. You check the weather forecast and learn that the chances of precipitation (sprinkles) in Seattle [Phoenix] are 30% [70%] during both days of your stay. How likely are you to take your umbrella with you to this trip?" We included "sprinkles" in the instructions to control for the expected amount of rain in all experimental conditions. Participants then indicated their likelihood of bringing an umbrella to this trip on an 11-point scale, with its endpoints anchored by the verbal labels "not likely at all" (0) and "for sure" (10).

Results

Fig. 1 depicts the mean rated probabilities for each condition. Supporting our central hypothesis that contextual factors influence the interpretation of small numerical probabilities to a greater extent than large numerical probabilities, there was a significant perceived base rate probability and probability magnitude interaction ($F(1, 162) = 3.95$, $p < .05$; $\eta^2 = .02$). When the chances of rain were 70%, those expecting to visit Seattle were no more likely to bring their umbrellas with them than were those expecting to visit Phoenix ($M_{\text{Seattle}} = 7.87$, s.d. = 2.51, vs. $M_{\text{Phoenix}} = 8.11$, s.d. = 2.38; $F(1, 162) = .15$, $p > .05$, $\eta^2 = .00$). When the chances of rain were 30%, however, those expecting to visit Seattle were reliably more likely to bring their umbrellas than were those expecting to visit Phoenix ($M_{\text{Seattle}} = 5.0$, s.d. = 3.07, vs. $M_{\text{Phoenix}} = 3.48$, s.d. = 3.37; $F(1, 162) = 5.90$, $p < .05$, $\eta^2 = .02$).

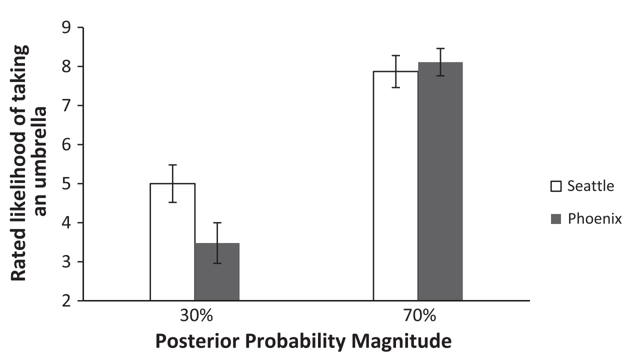

Fig. 1. Experiment 1A means. Bars represent the standard error of the mean.

Experiment 1b

We aimed to replicate this pattern with a separate sample of 149 participants, using 20% and 80% as the forecasted chances of rain. Replicating the effect with these two probabilities that are somewhat less ambiguous directionally than 30% and 70% (i.e., they are closer to the endpoints of the probability scale) would attest to the robustness of the effect.

There was again a significant subjective base rate probability and probability magnitude interaction ($F(1, 145) = 4.31$, $p < .05$, $\eta^2 = .01$), with participants indicating greater likelihood of bringing an umbrella to Seattle than to Phoenix when the forecasted chances of rain were 20% ($M_{\text{Seattle}} = 4.90$, s.d. = 3.32, vs. $M_{\text{Phoenix}} = 2.85$, s.d. = 3.28; $F(1, 145) = 11.68$, $p < .01$, $\eta^2 = .04$), but not when the forecasted chances of rain were 80% ($M_{\text{Seattle}} = 8.95$, s.d. = 1.49, vs. $M_{\text{Phoenix}} = 8.74$, s.d. = 2.00; $F(1, 145) = .10$, $p = .76$, $\eta^2 = .00$).

Discussion

Results from two initial studies support our central hypothesis that the perceived base rate probability of rain affects the interpretation of its numerical forecast more when the forecast involved low versus high probabilities. This finding is consistent with the contention that directional ambiguity of small numerical probabilities allows greater flexibility in their interpretation. Accordingly, perceptions of the dryness of Phoenix and raininess of Seattle affected the likelihood of bringing an umbrella more when the forecasted chances of rain were low (20% and 30%) than when they were high (70% and 80%).

To test the generality of the effect, in Experiment 2 we employed a different scenario, and asked directly about the subjective probability of the target event (rather than the predicted likelihood of engaging in a behavior based on the event's subjective probability). Replicating the observed interaction with this different dependent variable would support the interpretation that the locus of the effect is in fact the subjective probability of the target event, rather than some change in how a particular subjective probability translates into a behavioral prediction.

Experiment 2

We adapted a scenario from Windschitl and Weber (1999) involving a doctor's predicted probability of a specific patient with an ailment contracting malaria during a trip to either Hawaii or Calcutta. Windschitl and Weber (1999) manipulated only the target destination, keeping the forecasted probability of contracting the disease at 20% across conditions, and found the predicted contextual effect: a greater subjective probability of getting malaria in Calcutta than in Hawaii, despite the matched 20% forecast. In addition to testing whether the locus of the effect is indeed at the level of subjective probability, we wish to examine whether or not the effect Windschitl and Weber (1999) found for small probabilities would emerge for higher probabilities using the same scenario. To this end, we manipulated the magnitude of the predicted numerical probability, and asked participants to directly rate the subjective probability of the target event on a verbal probability scale.

Method

Participants and design

One hundred twelve undergraduate students, participating for class credit, were randomly assigned to one cell of a 2 (subjective base rate probability: lower/Hawaii vs. higher/Calcutta) × 2 (magnitude of predicted chances: 30% vs. 70%) between-subjects design.

Procedure

Participants were asked to consider the following scenario adapted from Windschitl and Weber (1999) on a computer.

> "Janet is planning to go on a year-long trip to Hawaii [India] where she will take a teaching position close to Waikiki beach [in Calcutta]. She is looking forward to combining work with play. Before leaving, her doctor gives her an extensive physical. During the physical, Janet finds out that she has a common blood condition that makes her more susceptible to certain ailments. Her doctor tells her that while in Hawaii [India], there is a 30% [70%] chance that she will contract a mild form of malaria. She is leaving for Honolulu [for Calcutta via Bombay] in a couple of weeks, and since she is your best friend, you will be sad not to have her around for the year."

Participants then rated, on an 11-point verbal probability scale, how likely they thought it was that Janet would contract malaria during her visit. The verbal probability scale was adapted from Windschitl and Weber (1999, experiment 1), with its endpoints anchored by the verbal labels "impossible" (0) and "certain" (10), and the midpoints anchored by the corresponding verbal probability labels.

Results

Fig. 2 depicts the mean rated probabilities for each condition. Replicating our central finding, there was a significant interaction between perceived base rate and probability magnitude ($F(1, 108) = 4.03$, $p < .05$, $\eta^2 = .02$): when the predicted chance of Janet contracting malaria was 30%, participants who were told that Janet was going to Calcutta judged her probability of contracting malaria as reliably higher than those who were told that Janet was going to Hawaii ($M_{Calcutta} = 4.87$, s.d. = 1.66, vs. $M_{Hawaii} = 3.77$, s.d. = 1.37; $F(1, 108) = 8.67$, $p < .01$, $\eta^2 = .04$). There was no difference in the subjective probability of Janet contracting the disease between the two cities, however, when the predicted chance of Janet contracting malaria was 70% ($M_{Calcutta} = 7.04$, s.d. = 1.18, vs. $M_{Hawaii} = 7.00$, s.d. = 1.29; $F(1, 108) = .01$, $p > .05$, $\eta^2 = .00$).

Discussion

Employing a different scenario, experiment 2 replicated that the impact of context is more pronounced on the interpretation of small than large numerical probabilities. Because the expected interaction emerged on a dependent measure that directly assessed the subjective probability of the target event, experiment 2 suggests that the locus of the effect is indeed at the level of subjective probability, rather than based on the context influencing the determination of a behavioral prediction or plan despite a constant level of subjective probability. Moreover, our results suggest that probability magnitude may be a moderator of contextual effects that Windschitl and Weber (1999) showed on subjective probability using the same scenario.

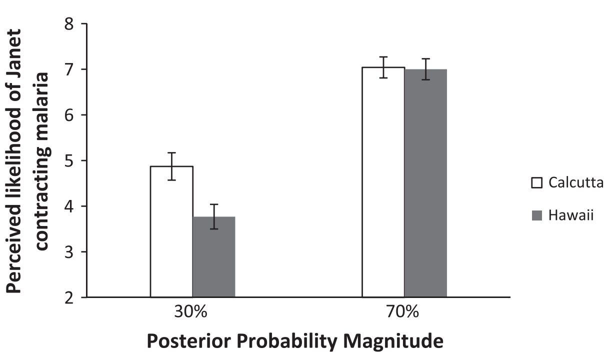

Fig. 2. Experiment 2 means. Bars represent the standard error of the mean.

The three studies so far employed a between-subjects manipulation of the forecast magnitude. Although this allowed us to show the asymmetric impact of perceived base rate probability on the interpretation of small and large numerical probabilities, it will be interesting to further examine which numerical probabilities are typically considered small probabilities, and thus are perceived as directionally ambiguous, and which ones are considered large probabilities, and thus are perceived as less directionally ambiguous. An intuitive prediction would be that numerical probabilities less than 50% might be considered small probabilities, and thus might be more susceptible to the influence of base rate probability on their interpretations compared to numerical probabilities above 50%. We also expected the interpretation of 50% to imitate the pattern for small probabilities because it can be considered to be the most directionally ambiguous percentage value (Teigen & Brun, 1999). Probabilities above 50% are predicted to be directionally unambiguous, and likely to be consistently interpreted positively.

Experiment 3

In experiment 3, we manipulated perceived base rate probability between-subjects and forecast magnitude within-subjects, to examine the impact of perceived base rate on the subjective probability of numerical probabilities across the entire probability range. We expected greater impact of perceived base rate on the subjective probability of posterior probability values below 50% due to their increased directional ambiguity.

Design and procedure

One hundred thirty-four undergraduate students participated in the experiment in return for class credit. The subjective base rate probability of rain was manipulated using the cities Seattle and Phoenix as in experiment 1. In order to emphasize to participants that weather forecasts already incorporate base rate probabilities for the target city, the instructions stated the following:

> "Weather forecasts are scientific predictions based on what happened in the past during conditions that are similar to the current weather patterns."

Then, on the same page, participants were asked to consider the following scenario: "Imagine that you live and go to school in Seattle, WA [Phoenix, AZ] and that today is a Sunday. The weather forecast for tomorrow, Monday is 70% chances of rain (sprinkles)." They were then asked to indicate their likelihood of bringing an umbrella with them to school.

Participants repeated this task for each of the following week - days for 18 numerical forecasts, which were randomly presented from a list of 18 possible forecasts (ranging from 10% to 90%). In order to be consistent with the expected difference in raininess across the two cities, the frequency with which each numerical forecast was presented was varied such that while the average forecast of rain for Seattle was 62.8%, it was 37.2% for Phoenix.

Results

Fig. 3a displays the average rated likelihood of bringing an umbrella for the different rain forecasts for each city. Fig. 3b displays the difference between the averages at each level. To account for the dependence of multiple judgments made by each participant, we computed the within-subject average of the judgments made at each probability level before comparing across the two conditions. Two-sample *t*-tests were then used to compare the average within-subject judgments across the two base-rate conditions at each level of forecast probability. Differences between the two conditions were statistically significant for probabilities between 10% and 50% ($ps < .05$), but not for probabilities between 60% and 90% ($ps > .20$). Hence, consistent with our central hypothesis, the difference in the likelihood of bringing an umbrella to Seattle versus Phoenix became more pronounced as the forecasted chances of rain got smaller.

The interaction between base rate and magnitude of posterior probability can also be illustrated by a comparison of the within-subject slopes relating judgments to the forecasted probability across the two cities. For each subject, we regressed the rated likelihood of bringing an umbrella on the stated forecast probability, and then compared the average regression slope across the two base rate conditions. The within-subject standard errors were aggregated to account for the multilevel structure of the model. The average within-subject slope was higher for Phoenix ($b = 10.56$, s.e. = .14) than for Seattle ($b = 9.68$, s.e. = .13; $t(132) = 4.4$, $p < .01$). This difference is consistent with subjective probabilities for two cities being comparable for high posterior probabilities, but dropping more steeply to a lower level for Phoenix when the forecasted probability is low.

Discussion

Experiment 3 replicated the interaction found in the earlier experiments using a within-subject design: perceived base rate affected the interpretation of small numerical probabilities more than large ones. Interestingly, the interpretation of the very small probability of 10% chance of rain, which it may seem would be relatively directionally unambiguous, was also susceptible to the impact of subjective base rate probability. This is in line with Teigen and Brun (1995, experiment 3) who found the same directional ambiguity for the 10% level. Evidently, there is a strong positivity bias in interpreting even quite small numerical probabilities.

Experiment 4

We next examine more directly whether a confirmatory hypothesis testing process may underlie the generation of subjective probabilities for directionally ambiguous numerical probabilities.

Hypothesis testing has been shown to underlie probability estimations (Sanbonmatsu et al., 1997), among other judgments. Prior research has manipulated the focal hypothesis participants tested to infer the hypothesis that they naturally test, providing evidence for a hypothesis testing process (e.g., Sanbonmatsu et al., 1997). Likewise, in experiment 4, we manipulated the focal hypothesis participants were explicitly asked to test given the task of interpreting directionally ambiguous numerical probabilities. That is, while some participants were asked to generate either positive or negative reasons for rain in the target city, others were not asked to generate any reasons (i.e., control group). The pattern of results from these conditions can suggest which hypotheses people are naturally testing when not asked to generate reasons.

Specifically, if a directionally ambiguous numerical probability is interpreted in the direction suggested by the perceived base rate probability, as we propose, then the interpretations of those plan-

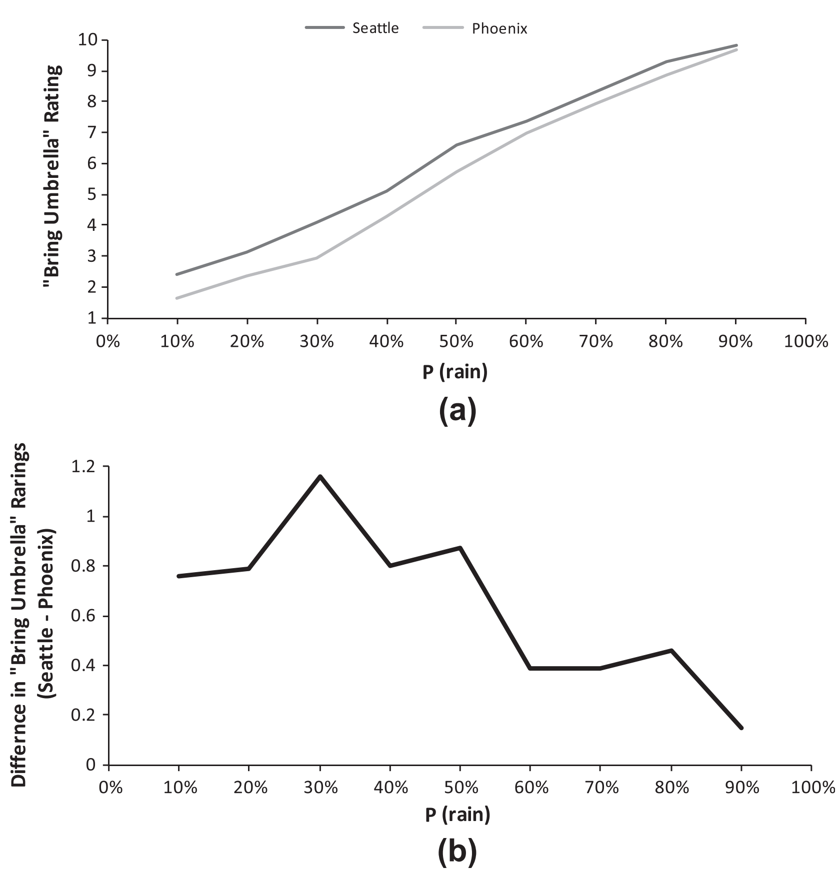

Fig. 3. (a, top) Average ratings of likelihood of bringing an umbrella in Experiment 3, by city and forecasted rain probability. (b, bottom) Differences in the rated likelihood of bringing an umbrella in Experiment 3, by forecasted rain probability.

ning to visit Seattle should not be affected by instructions to generate reasons as to why it may rain there relative to a no-reasons control group. This is because participants in the control group should be naturally testing the hypothesis of "rain" for Seattle, leading to a positive interpretation of the directionally ambiguous posterior probability. However, prompting participants to test the focal hypothesis of "no rain" for Seattle, which is unlikely to be focal given the accessible "rain" hypothesis suggested by the base rate, should encourage a more directionally negative interpretation of the numerical forecast. This should in turn reduce the subjective probability of rain, and the likelihood of bringing an umbrella to Seattle relative to the control condition.

The opposite should be true for those expecting to visit Phoenix, however. Prompting participants to test the negative hypothesis of "no rain" should not affect the interpretation of the numerical forecast relative to the no-reasons control group. This is because control group participants should naturally test the focal hypothesis of "no rain" as suggested by the low perceived base rate probability of rain in Phoenix. But prompting participants to generate reasons for "rain" in Phoenix should encourage a more directionally positive interpretation of the numerical forecast, which should increase the subjective probability of rain, and the likelihood of bringing an umbrella. If supported, these patterns would provide support for the hypothesis testing account, and the spontaneous nature of testing a focal hypothesis implied by the perceived base rate as a means to interpret directionally ambiguous numerical probabilities.

Method

Participants and design

Three hundred sixty-four undergraduate students, participating for class credit, were randomly assigned to one cell of a 2 (subjective base rate probability: Phoenix vs. Seattle) × 3 (reasons considered: positive, negative, control) between-subjects design.

Procedure

The procedure was similar to experiment 1 except that before indicating their likelihood of bringing an umbrella to their planned trip, participants were informed of the 20% chances of rain in the city they were planning to visit and asked to generate a reason why they may (positive-reason condition) or may not (negative-reason condition) expect rain, depending on condition. Participants in the control condition were not asked to generate any reasons for either rain or no rain, and went onto rate their likelihood of bringing an umbrella after learning about the forecasted chances of rain in the target city.

Results

Fig. 4 depicts the average ratings. A 2 × 3 between-subjects ANOVA revealed significant main effects for both the perceived base rate probability ($F(1, 358) = 38.86$, $p < .01$, $\eta^2 = .09$) and reasons-considered manipulations ($F(2, 358) = 8.77$, $p < .05$, $\eta^2 = .04$). As predicted, these main effects were qualified by a perceived base rate probability and reasons considered interaction ($F(2, 358) = 2.97$, $p = .05$, $\eta^2 = .01$).

We evaluated orthogonal contrasts among the conditions to test the hypothesized effects. For Seattle, we predicted that the positive-reason and control conditions should be similar, and yield higher ratings than the negative-reason condition. Indeed, the average umbrella rating in the negative-reason condition ($M_{\text{Negative-reason}} = 5.09$, s.d. = 3.11) was lower than that in the combined control and positive-reason conditions ($M_{\text{Control–positive-reason}} = 6.73$, $F(1, 358) = 10.85$, $p < .01$, $\eta_2 = .03$). Furthermore, there was no significant difference in the likelihood of bringing an umbrella

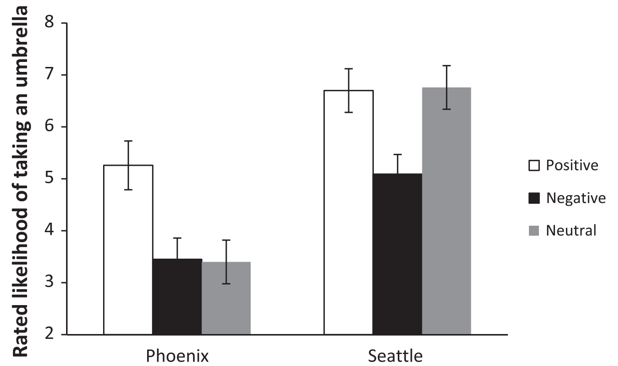

Fig. 4. Experiment 4 means. Bars represent the standard error of the mean.

between the positive-reason and control conditions ($M_{\text{Positive-reason}} = 6.70$, s.d. = 3.40, vs. $M_{\text{Control}} = 6.76$, s.d. = 3.03, $F < 1$, $\eta^2 = 00$).

For Phoenix, we predicted that the negative-reason and control conditions should be similar, and yield lower ratings than the positive-reason condition. Supporting these predictions, the average rating in the positive-reason condition ($M_{\text{Positive-reason}} = 5.26$, s.d. = 3.65) was greater than that in the combined control and negative-reason conditions ($M_{\text{Control–negative-reason}} = 3.42$, $F(1, 358) = 12.64$, $p < .01$, $\eta^2 = .03$), as expected. There was no significant difference in the likelihood of bringing an umbrella between the negative-reason and control conditions ($M_{\text{Negative-reason}} = 3.45$, s.d. = 3.14, vs. $M_{\text{Control}} = 3.40$, s.d. = 3.21, $F < 1$, $\eta^2 = 00$).

What reasons did participants provide when prompted? When asked why they would expect rain in Seattle, participants typically mentioned the fact that it is a rainy city, referring to the high base rate probability of rain. Such responses included "Seattle is known for rainy days so I would expect it.," and "Seattle is notorious for rain." Notably, many responses mentioned both the base rate and the posterior (forecasted) probability, suggesting that the high base rate of rain in Seattle encouraged positive interpretations of the directionally ambiguous posterior probability. One participant noted: "Because the forecast called for a 20% chance of precipitation and because Seattle is one of the wettest cities in the US." This statement nicely illustrates a directionally-positive interpretation of the low 20% forecast; the participant is focusing on how the forecasted probability, while quite low, still allows for the possibility of rain. Another participant: "I might expect some rain during my visit because there is some chance of rain. It is not 0%. Also, my perception of Seattle might make me more apt to thinking that it will rain. Seattle is known for its precipitation." And a third: "Because it's common knowledge that Seattle is a really rainy city and because the forecast predicts it will."

When asked why they would *not* expect rain in Seattle, participants tended to mention the small posterior probability itself to justify no rain, interpreting it negatively, and did not mention the perceived base rate. Such examples included "Because there is an 80% chance of no rain.", "There is only a 20% chance that it will rain, so there is an 80% chance it will not.", and "The chance is only 20%, making it more likely not to rain, than to rain."

Responses for Phoenix followed a similar pattern. When asked to provide a reason why it would not rain in Phoenix, participants typically mentioned the dryness of the city, referring to the low base rate probability of rain. Again, many participants mentioned both the base rate and the posterior probability, suggesting that the low perceived base rate probability of rain might have biased participants to interpret the direction of the forecast negatively. Some of these responses included "Because there is an 80% chance it will not rain, not to mention the fact that it's a desert.", "The chance for rain is not very high and it rarely rains in Phoenix.", "A forecast of 20% (especially in the desert) isn't strong prediction for rain", and "Because Phoenix is in the desert so I assume it doesn't rain much, and especially since it's only 20% chance."

When asked to provide a reason why they would expect rain in Phoenix, participants tended to mention the small posterior probability itself to justify rain, interpreting it positively, and did not mention the perceived base rate. Some examples included "Duh... the forecast. And fog and humidity", "Because the weather forecast – which is usually correct – says so!", "Because the forecast told me there is a chance of rain."

Discussion

Experiment 4 results are consistent with the premise that one way people interpret directionally ambiguous numerical probabilities is by testing the focal hypothesis suggested by the perceived base rate. Results suggest that the perceived base rate influences the focal hypothesis people test, effectively determining the direction of interpretation for an otherwise directionally ambiguous numerical probability. Whether the direction of interpretation is positive or negative in turn affects the event's subjective probability, presumably by biasing the evidence people recruit to interpret the directionally ambiguous numerical probability.

In particular, prompting participants to consider reasons for "no rain" in Seattle reduced their likelihood of bringing an umbrella relative to the control and positive-reasons conditions. This difference arose presumably because control group participants naturally considered reasons for "rain" in Seattle, which encouraged a positive interpretation of the directionally ambiguous probability. Further supporting this premise, prompting participants to consider reasons for "rain" in Seattle did not increase their likelihood of bringing an umbrella relative to the control group. For Phoenix, however, forcing participants to consider reasons for "rain" increased their likelihood of bringing an umbrella relative to the control and negative-reasons condition. This effect arose presumably because control group participants naturally considered reasons for "no rain" in Phoenix, a city strongly associated with dryness, which encouraged a negative interpretation of the directionally ambiguous numerical probability. As expected, forcing participants to consider reasons for "no rain" in Phoenix did not decrease their likelihood of bringing an umbrella relative to the control group.

Examples of typical reasons participants provided for or against rain in response to instructions to do so appear to support the notion that the same numerical probability may be interpreted positively or negatively depending on the direction of interpretation suggested by the perceived base rate. That this effect occurred in the absence of an explicit statement of the base rate suggests that a strong associative link of the base rate with the target event may be necessary for the effect to arise, a topic we will return in the General Discussion. Results further suggest that prompting participants to consider the hypothesis opposite to that suggested by the perceived base rate may correct for its bias on the interpretation of the numerical probability.

Finally, experiment 4 also illustrated that participants indeed perceived the hypothesized, but not explicitly stated base rates for rain in Phoenix and Seattle as intended, as the reasons cited for or against rain in the two cities suggest (e.g., it rarely rains in Phoenix; Seattle is one of the wettest cities in the US). Moreover, the almost identical means of the respective control conditions with the negative-reason condition for Phoenix and the positive-reason condition for Seattle suggest that control group participants (who were not given a hypothesis to test) indeed associated Phoenix with dryness, and Seattle with rain.

General discussion

In five experiments, we examined how context affects the interpretation of precise but directionally ambiguous numerical probabilities. Consistent with the premise that small numerical probabilities can be more directionally ambiguous than large ones, we find that their interpretation is more susceptible to contextual influence by perceived base rate. The effect emerged in predicted likelihood of engaging in a behavior based on the event's subjective probability (experiments 1, 3, and 4). Experiment 2 generalized the effect to a direct measure of subjective probability (experiment 2), suggesting that its locus is indeed at the level of subjective probability. The pattern of data is consistent with a confirmatory hypothesis testing process, which appears to drive the translation of perceived directionality into subjective probabilities.

Although prior work showed that the representativeness of the target event affects the interpretation of numerical probabilities (Windschitl & Weber, 1999), the current work suggests that probability magnitude moderates these contextual effects on subjective probability. Also, the current research goes beyond prior work that examined whether people simultaneously hold the belief about the objective probability of an event while having intuitive perceptions about whether the event will occur (Windschitl & Weber, 1999) by examining how people may generate a subjective sense of an event's likelihood in the first place. Experiment 4 findings suggest that hypothesis testing may be one mechanism through which people may make sense of a directionally ambiguous numerical probability by recruiting evidence for or against the focal event. Hypothesis testing seems susceptible to the influence of context in that perceived base rate may determine, associatively, the focal hypothesis judges consider and then proceed to test in a biased fashion.

To test our predictions, we used scenarios in which we think the provided forecasts are clearly interpretable as posterior probabilities. A weather forecast scenario was used in several of the experiments in part because such forecasts are naturally and familiarly interpreted as posterior probabilities, hence providing an excellent domain to test our predictions. First, such forecasts are explicitly specific to a location and a time. Second, people routinely check and conveniently utilize updated forecasts to plan accordingly. The common use of weather forecasts in this fashion suggests that participants have a sense of the fact that the rain forecast for a city already incorporates the base rate of rain for that city. One reason is that weather forecasts would be rather difficult to utilize if they had to be combined with other information such as the base rate for the target city to compute a posterior probability. The inconvenience of discovering the base rate of rain to meaningfully interpret the forecast for an unfamiliar city contrasts with the common and convenient use of weather forecasts in daily life. That the predicted interaction continued to emerge despite a reminder of the forecast already incorporating the base rate of rain to participants (in experiment 3) suggests the questionable use of base rates to interpret posterior probabilities. Interestingly, this effect arose in the absence of an explicitly stated base rate that is nevertheless strongly associated in memory with the target event.

Experiment 2 used a scenario adapted from Windschitl and Weber (1999) to examine whether the observed interaction generalizes to a different context and dependent measure. This scenario also explicitly specified the location and time for the doctor's forecast of a given individual contracting malaria (e.g., "while Janet is in India"). These features of the scenario served our purposes by highlighting the fact that the expert's forecast is the posterior probability of an individual contracting malaria, and is not a general likelihood statement. Windschitl and Weber (1999) assumed that malaria was more strongly associated with Calcutta than Honolulu, and found results consistent with this assumption.

Although the presumed associations may seem plausible if malaria is typically associated with the tropics where both cities are located, and India is more strongly associated than the US with malaria, they have not been fully verified empirically. Nevertheless, experiment 2's results, as well as the results of Windschitl and Weber (1999) are consistent with our premise of context affecting the interpretation of small but not large posterior probabilities.

Base rate neglect

Prior research has shown that, in the presence of case-specific data, people tend to underuse base rate or class information, even when such information is explicitly provided in the experimental task (Kahneman & Tversky, 1973). Base rates are found to be properly utilized only when they are perceived as causally related to the event in question, when they are stated in a specific manner, or when they are concrete or vivid (Bar-Hillel, 1983). In the traditional base rate paradigm, participants are typically provided with the base rate probability of an event and its likelihood to arrive at its posterior probability, which they then use to make related judgments. Base-rate neglect arises when participants focus nearly exclusively on case-specific evidence at the expense of base rate information when calculating the posterior probability. Minimal use of base rate information in this paradigm is taken as evidence showing that people are not Bayesian updaters.

The current experiments deal with a quite different situation than the Bayesian updating tasks. Unlike the typical base rate neglect experiment that employs the posterior probability as the dependent variable, the current experiments provided participants with a posterior probability that has already incorporated the base rate probability. Hence, even the minimal use of base rate probability when provided with the posterior probability is puzzling. Given a posterior probability, neglecting the base rate is the appropriate course of action, so to speak. Yet, the base rate continued to influence the interpretation of directionally ambiguous low probability forecasts even when it was not explicitly stated. Ironically, participants' potentially inappropriate use of base rate probability in the current studies provides a contrast to the inappropriate neglect of explicitly provided base rate information in prior Bayesian belief-updating studies.

One reason that may explain both the potentially inappropriate use and neglect of base rate information in these two paradigms may pertain to the associative strength of base rate information. Demonstration of base rate neglect in belief-updating tasks usually entailed participants applying abstract formal rules to incorporate the base rate information, which typically lacked in associative strength with the target event. Compelling case-specific information with high associative strength was highly salient, however, and overwhelmed any potential use of the base rate. Other research showed that people were able to incorporate base rate information appropriately when such information was a natural output of associative processes. For example, doctors appropriately used base rate information when it was an output of the automatic retrieval of symptom-diagnosis associations from their memory (Weber, Böckenholt, Hilton, & Wallace, 1993). This notion is also consistent with the associative nature of perceived base rate probability in the current experiments, in which the only information available to participants to generate the perceived base rate was the retrieval of associations between Seattle and rain, and Phoenix and dryness from memory. Likewise, in line with Windschitl and Weber (1999), we suspect that different retrieved associations between malaria and India (vs. Hawaii) drove the interaction in experiment 2, as these associations were also not explicitly provided to participants. As such, the associative nature and strength of base rate information that improved decision making in the "base rate neglect" paradigm led to its potentially inappropriate use in the current context, impoverishing decision making.

Finally, our experiment 4 results suggest that the effect of the potentially inappropriate use of base rate information can be effectively eliminated by instructions or cues to consider opposing evidence. Such cues may counteract the associative influence of the perceived base rate on determining the focal hypothesis, and subsequent biased recruitment of evidence, effectively serving as a debiasing technique.

Alternative explanations

We proposed that the use of perceived base rate to interpret the posterior probability in the current paradigm may be normatively inappropriate since the posterior probability (the forecast of rain for a specific day; a doctor's forecast of a specific individual contracting a disease) already incorporates the base rate. One may nevertheless argue that participants interpreted the forecasts not as posterior probabilities, as we propose, but simply as new data indicating partially diagnostic evidence for rain. By this interpretation, even though the forecasts are expressed as numerical probabilities, they are interpreted as relative measures of evidence strength: the higher the forecast, the greater the evidence for rain. Call this the "skeptical weather consumer" view, because it implies that the viewer does not believe that the weather forecaster is actually providing a probabilistic forecast. Perhaps they interpret the statement of a "90% chance of rain tomorrow" as something like "most of the data point towards rain." If indeed people interpret the forecasts as measures of evidence strength, then calculating a subjective posterior probability would require combining the diagnostic value of the forecast with what people already know about the overall weather propensities in the target city. In effect, the task would become more like a traditional belief updating task, in which the given forecast is not to be interpreted as the true posterior probability, but rather a piece of diagnostic data that needs to be integrated with a relevant base rate. Under this interpretation of the weather forecast, the use of the location's overall base rate to compute the posterior probability makes Bayesian sense.

Although it is possible for some of our participants to have misinterpreted the posterior probability as diagnostic data to be combined with base rate information, we believe that it is unlikely to be a systematic tendency, and overall a less satisfactory explanation for the full pattern of data than the proposed hypothesis testing account. First, the instruction regarding the interpretation of the forecast in experiment 3 clearly conveyed that a forecast combines "past" information (base rate) with the "current weather patterns" (data). Second, perhaps more importantly, while this account may help explain the use of perceived base rates for low numerical forecasts in the current scenarios, it fails to account for their lack of use for high numerical forecasts.

One way to account for the interaction may be that high numerical forecasts are interpreted as posterior probabilities, while low numerical forecasts are interpreted as new data. This account, however, seems rather implausible as it is not clear why the interpretation of a forecast as a posterior vs. diagnostic evidence should vary based on its magnitude. This view still requires some rationale for the interaction with the magnitude of the forecast. In sum, although it is possible that some of our participants interpreted the forecast as new data, this tendency is unlikely to systematically hold across participants, considering the observed interaction between probability magnitude and perceived base rate.

Another alternative explanation involves participants interpreting the precise numerical forecast as representing a range of possibilities. For example, a 30% chance of rain might be interpreted as representing a chance of rain between 20% and 40%. It is possible that people may prefer to create intervals around precise numerical forecasts so as to incorporate the perceived inaccuracy of weather forecasts into their interpretation. If so, the use of perceived base rates to determine where the posterior probability falls within the range may seem justified. As with the skeptical weather consumer view, this account also fails to plausibly account for the observed interaction, however. That is, small numerical forecasts should be perceived as less accurate than large numerical forecasts to account for base rate use for small but not large numerical probabilities. It is not clear why this should be the case, however. Alternatively, one may argue for a ceiling effect to account for the interaction, with the range of large numerical probabilities compressed by the upper limit of the probability scale. This should in turn reduce the impact of base rates on the interpretation of high numerical forecasts. However, the fact that the significant effect of base rate failed to emerge for probabilities as low as 60% in experiment 3 markedly reduces the plausibility of a ceiling effect argument to account for the interaction.

It is possible that participants may have misinterpreted the predicted chance of Janet contracting malaria as a general likelihood statement in experiment 2. If so, the discrepancy between the perceived base rate and the "stated general likelihood" of 70% should be larger for Hawaii than Calcutta because the perceived base rate of malaria should be lower in Hawaii. Prior research suggests that such large discrepancy should produce a contrast effect of base rate, with subjective probability seeming larger for Hawaii than Calcutta in the high probability condition (Herr, Sherman, & Fazio, 1983; Teigen & Brun, 2000). That there was no effect of base rate in this condition, however, suggests the possibility that the aforementioned discrepancy may have made participants reluctant to use the base rate of malaria to interpret the posterior probability. Hence, if participants have strong beliefs about malaria transmission, it is possible that their skepticism of the information given might contribute to the interaction observed in experiment 2.

Assimilation vs. contrast effects of context

Teigen and Brun (2000) found that prior expectations lead to a contrast effect on perceived directionality, with even a low probability of rain for a dry city encouraging the generation of reasons as to why it should rain there. This contrasts with our findings that show an assimilation effect of context. One reason for this discrepancy may have to do with Teigen and Brun's (2000) prior expectation manipulation. To illustrate with a stimulus employed in their experiment, participants estimated the probability of Scandinavian Airlines flights being on schedule to be about 74%, but they were told in the experiment that this probability was actually 25% (or 30%). Participants' descriptions of such unexpectedly low probabilities as "only 25% (or only 30%)" were interpreted as evidence for a contrast effect of prior expectations. Prior research suggests that such extreme examples do lead to contrast effects (Herr et al., 1983). On the other hand, the posterior probability in our experiments is for a specific day or a specific patient only, and there are many days in Seattle for which the rain forecast is 20% or 30%, which makes the forecast atypical perhaps but not extreme.

Another relevant difference between Teigen and Brun (2000) and the current work is that those researchers used a sentence completion task to examine the perceived directionality of ambiguous numerical probabilities. Although this task establishes directionality effectively, it explicitly involves controlled processes in interpreting numerical probabilities. Prior research has shown that contrast effects are typically products of controlled processes that expend significant cognitive resources (Martin, Seta, & Crelia, 1990). When context or level of motivation does not encourage such effortful processing, however, assimilation effects typically arise (Pelham & Wachsmuth, 1995). Because we were interested in the associative, more automatic effects of context on perceived directionality and subjective probability, we employed tasks and measures that did not explicitly encourage controlled processes likely to override the associative effects we were interested in. Another related aspect of Teigen and Brun's (2000) research that potentially limited the impact of associative influences on their measures was their stimuli, which were arguably not as rich associatively as those used in the current experiments (e.g., flights being on time). As such, prior expectations were likely to have been generated in a more controlled manner in their experiments, which is more likely to induce a contrast effect. In sum, the associative nature of the current effects may have made an assimilation effect of context more likely relative to prior work that employed the more controlled task of sentence completion to study perceived directionality.

A limitation of the current research involves the use of only low probabilities in experiment 4. Because large probabilities were not used in this experiment, the current results cannot speak to the issue of whether event-context associations are not activated or only weakly activated, or their use is successfully inhibited when judges interpret directionally less ambiguous large numerical probabilities. Further research is needed to better understand the factors that shield the interpretation of large, directionally less ambiguous numerical probabilities from the often undesirable impact of contextual factors.

Consistent with the expectation that numerical probabilities should be less susceptible to "undesirable individual difference and context effects" (Weber & Hilton, 1990, p. 789) owing to their precision, opportunity for miscommunication is believed to be higher for verbal than numerical risk communication (Budescu, Weinberg, & Wallsten, 1988). The current results qualify these conclusions by suggesting that small numerical probabilities may be more prone to misinterpretation than large ones due to their directional ambiguity. Moreover, the fact that the effect of base rate occurred in the domain of particularly well-calibrated weather forecasts suggests that it may be just as likely to arise in other, arguably not as well-calibrated forecasting domains. If true, then while communicating medical risk, for example, one should be particularly careful in conveying low-likelihood probabilistic diagnoses. Our results suggest that the interpretation of a 30% likelihood of developing a condition is more likely to be affected by contextual factors than a 70% likelihood of developing the same condition, suggesting the use of extra measures to reduce possible confusion induced by the directional ambiguity of the former diagnosis. Our results suggest that it may be preferable to reframe probabilistic forecasts in terms of events of high likelihood where it is feasible to do so.

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