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

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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

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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