



# 9

## Base Rates *How to Make the Intuitive Mind Appreciate or Neglect Them*

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### INTRODUCTION

**I**n his book *Bully for Brontosaurus: Reflections in Natural History*, the late Harvard paleontologist Gould (1992) concluded that “our minds are not built (for whatever reason) to work by the rules of probability” (p. 469). Coming from a scientist whose thinking was deeply rooted in evolutionary theorizing, this proclamation was, well, unexpected. It implies nothing less than that our cognitive machinery is somehow out of synchrony with the probabilistic structure of the world. Gould’s epiphany was inspired by the findings of one of the most influential, recent research programs in cognitive psychology: the heuristics-and-biases program (e.g., Kahneman, Slovic, & Tversky, 1982). According to this program, when dealing with the twilight of uncertainty, people rely on a limited number of simplifying heuristics rather than more formal and computationally and informationally more extensive algorithmic processing. The heuristics are regarded as typically yielding accurate judgments but also giving rise to systematic errors. Recently, the heuristics, often regarded as “general purpose heuristics—availability, representativeness, and anchoring and adjustment” (Gilovich, Griffin, & Kahneman, 2002, p. xv), have been identified with a mental system akin to “intuition” (see Epstein, chap. 2, this volume; Epstein, 1994; Stanovich & West, 2000).

One key domain in which intuitive judgment—embodied in terms of simple, general-purpose heuristics—departs from what is taken to be good judgment is belief updating. When updating their beliefs, good judges should respect Bayes's theorem. It defines how one should integrate prior probability, summarizing what one knew about the problem, with independent specific evidence.<sup>1</sup> Because of their reliance on simple heuristics such as representativeness, people, according to Kahneman and Tversky (1973), fail to appreciate the relevance of prior probability in the presence of specific evidence. This failure, the so-called base-rate fallacy, is “perhaps one of the most significant departures of intuition from the normative theory of prediction” (Kahneman & Tversky, 1973, p. 242).

For many years, the “base-rate fallacy, with its distinctive name and arsenal of catchy and counterintuitive illustrations . . . had a celebrity status in the literature” (Koehler, 1996, p. 1); and one influential review confidently concluded, “The genuineness, the robustness, and the generality of the base-rate fallacy are matters of established fact” (Bar-Hillel, 1980, p. 215). In the 1990s, however, a controversial debate over whether people are able to reason in a Bayesian way (see Koehler, 1996) and on the robustness and interpretation of systematic errors in probabilistic reasoning more generally (e.g., Gigerenzer, 1996; Kahneman & Tversky, 1996) arose. Interestingly, this debate has taken little note of the fact that other faculties of the human mind, in particular, human perception and memory, are assumed to effectively approximate optimal statistical inference, thus correctly combining new data with a veridical probabilistic mental model of the environment (e.g., Anderson & Milson, 1989; Anderson & Schooler, 1991; Freeman, 1994; Knill & Richards, 1996; Körding & Wolpert, 2004; Simoncelli & Olshausen, 2001). Only recently, Griffiths and Tenenbaum (2006) highlighted this striking discrepancy: intuitive cognitive judgments under uncertainty that are being portrayed as the result of error-prone heuristics, insensitive to prior probabilities, versus the near optimality of other human capacities.

Our goal in this chapter is to help to reconcile these conflicting conclusions. We begin by providing an illustration of some representative yet conflicting findings from the psychology of intuitive judgment and of visual cognition. Then, we turn to a potential way of reconciling them.

## INTUITIVE AND VISUAL COGNITION: CONCURRENT BASE-RATE NEGLECT AND BASE-RATE SENSITIVITY

Tversky and Kahneman (1974) reported a classic demonstration of neglect of base-rate information in a probabilistic reasoning task, the “engineer-lawyer problem.” Participants were told that a panel of psychologists had written personality descriptions

<sup>1</sup> Bayes's theorem is a rule for revising a prior probability, or base rate (as it is often called) into a posterior probability after new data have been observed. According to the theorem, the posterior probability is:  $p(H_1|D) = p(H_1) p(D|H_1)/p(D)$ . In odds form, Bayes's theorem tells one how much confidence people should retain in the relative validity of two hypotheses once they learn outcome D has occurred.

of 30 engineers and 70 lawyers based on the results of personal interviews and personality tests. Then they learned that five descriptions had been chosen at random from this pool. After reading these descriptions, participants assessed the probability that each of the persons described was an engineer (low base-rate condition: 30% engineers). Other participants were given the same descriptions and task but with 70 engineers and 30 lawyers (high base-rate condition: 70% engineers).

People's sensitivity to these base rates, or the lack thereof, can best be illustrated with one of the personality descriptions that was constructed to be totally uninformative with regard to the person's profession. It read as follows:

Dick is a 30-year-old man. He is married with no children. A man of high ability and motivation, he promises to be quite successful in his field. He is well liked by his colleagues.

With the provision of this worthless piece of evidence, Bayes's theorem predicts that the posterior probabilities in the low and high base-rate conditions should map onto the respective base rates. Instead, the base-rate information had a weak (although significant) effect on participants' judgments. The probability that Dick was a lawyer was estimated to be 50% and 55% for the low and high base-rate conditions, respectively. Kahneman and Tversky (1973) concluded "When worthless specific evidence is given, prior probabilities are ignored" (p. 242). Kahneman and Tversky (1973) termed this behavior *base-rate neglect*.<sup>2</sup>

In a study of visual cognition, Simons and Levin (1997) provided an ingenious demonstration that people behave as though they strongly relied on base-rate information. Simons and Levin's participants saw a video showing an experimenter who approaches a pedestrian to ask for directions. While the pedestrian is providing directions, two workers carrying a door rudely pass between the experimenter and the pedestrian. During this brief interruption, a different person replaces the original experimenter. Even though the two people look quite different and have distinctly different voices, about 50% of the participants, watching the video, failed to notice that the person asking the question has changed. One way to interpret this "blindness to change" is that many people place too much faith in the base rates, here the base rate of the interlocutor permanence (i.e., typically, a person with whom one is conversing is not suddenly replaced with another).<sup>3</sup>

<sup>2</sup> Subsequent studies have demonstrated that certain variables can decrease people's tendency to neglect base-rate information. For example, base rate is less likely to be ignored when it is perceived to be causally relevant (Ajzen, 1977; Tversky & Kahneman, 1982), when participants themselves performed and observed the random sampling of information (e.g., the personality description; Gigerenzer, Hell, & Blank, 1988; Nisbett & Ross, 1980), and when it is learned from experience (Betsch, Biel, Eddebüttel, & Mock, 1998). Nevertheless, almost all studies that have focused on Dick-like problems appear to support the view of insufficient use of base-rate information in intuitive judgment. Indeed, some researchers (notably Cohen, 1981) have actually criticized this line of research and have said that it shows such trivial results that base rate should be neglected in these situations.

<sup>3</sup> Additional illustrations of the effect of base rates and prior probabilities in visual cognition can be found in Biederman, Mezzanotte, and Rabinowitz (1982); Eisenberg and Becker (1982); Foss (1969); Frost and Katz (1989); Grainger and Segui (1990); and Howes (1957).

## THE IMPACT OF MERE PRESENTATION

To reconcile the conflicting results and conclusions drawn in research on probabilistic reasoning and visual cognition, respectively, we focus on one distinct property of the experimental settings that may cause these opposite behaviors, namely, the stipulation of possible responses. For illustration, we return to the engineer-lawyer problem. In that study (Tversky & Kahneman, 1974), participants were explicitly told that the 30-year-old Dick “was either a lawyer or an engineer.” In the blindness-to-change study (Simons & Levin, 1997), in contrast, people were not told that the questioner may or may not have changed. Rather, people’s awareness of the change or lack thereof was inferred from their answers to other questions. This difference matters. Erev, Leybman, and Hertwig (2005) suggested that the mere presentation of possible responses involving events or event categories increases the impact of a priori less likely categories.

The effect of mere presentation can be explained in terms of a dilemma that any person considering base rates faces. On which of the often-infinite possible categories and associated base should one focus? Take as an example the blindness-to-change study (Simons & Levin, 1997). At any given moment, the environment could change or be changed in an infinite number of ways. Keeping track of and monitoring these countless ways in which the world could change is impossible for any real person; real people navigate the world under the constraints of limited time, knowledge, and computational capacities (see Gigerenzer, Todd, & the ABC Research Group, 1999; Simon, 1991). Thus, real people cannot help but ignore the infinite potential for change and instead bet on a rather stable world or bet on changes that have a high a priori likelihood (or a high base rate of occurrence). There are occasions, however, when these defaults need to be revised. One cue that is likely to prompt revision is the explicit presentation of a priori unlikely events or event categories. In other words, unlikely categories—such as the change of the interlocutor during a conversation—are more likely to be considered when their possible occurrence is explicitly invoked. People may be even more inclined to take a priori unlikely events into account if the unlikely categories have been explicitly called on by a third party: a party who is assumed to obey a basic principle of communication, namely, cooperativeness, and subordinate maxims such as that of relevance (Grice, 1975; Hilton, 1995). Explicitly bringing into play a rare category—as the sender of a message (e.g., an experimenter)—is likely to prompt the receivers to treat this category as more probable than they would do otherwise.

In what follows, we describe three intentionally simple studies that demonstrate the impact of merely mentioning response categories on the appreciation or lack thereof of base rates.

## THE EFFECT OF MERE PRESENTATION IN PERCEPTUAL IDENTIFICATION

The first demonstration (Study 1) involves a visual stimulus used in a classic visual cognition experiment. It involves a variant of the “B 13” example used by Bruner and Minturn (1955; and see Kahneman, 2003). Our question is the following: Will

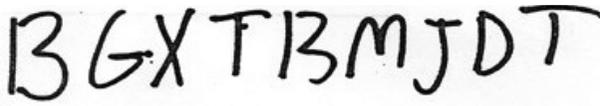


FIGURE 9.1 Stimulus used in Study 1.

the explicit presentation of two possible responses diminish the effect of prior knowledge (of relevant base rates)?

To find an answer, we employed a between-subject design with two experimental conditions. Participants in the memory and decision condition saw a series of stimuli, and we asked them to memorize it. We also asked them to decide whether the stimulus in the center of the series—see Figure 9.1—represented the letter “B” or the number “13.” Subsequently, they reconstructed the series. Participants in the memory condition encountered the same series but were asked merely to memorize and then reconstruct it. For our purposes, we analyzed only the interpretation of the ambiguous symbol that could be read to be either a letter or a number. The memory condition enabled us to examine the interpretation of this symbol without the experimenter having invoked the number.

One class of 75 industrial engineering and economics students from the Technion, Israel, participated in the experiment. The average age was 25, and about 50% of the participants were males. We assigned students on the right side of the classroom ( $n = 41$ ) to the memory condition, and we assigned students on the left side ( $n = 34$ ) to the memory and decision condition. Students in the memory and decision condition read the following instructions:

A list of stimuli is about to be presented in front of you for 10 seconds. During the presentation, your task is to learn the list by heart (and to decide whether the stimulus in the center is a “B” or a “13”). You will then be asked to remember the list from memory.

The instructions in the memory condition were identical, except for the omission of the decision instruction (the phrase enclosed in parentheses).

How did the suggestion of an unlikely event change people’s judgment? Of the 41 students in the memory condition, only 4 remembered having seen a 13; 28 remembered having seen a B, and 9 did not remember it at all. In contrast, in the memory and decision condition, 14 of the 34 students reported that they saw a 13, 18 thought that the symbol represented a B, and 2 failed to remember it.

Excluding the students who did not remember the critical stimulus, the proportion who believed they had seen a 13 was significantly higher ( $z = 2.78, p < .01$ ) in the memory and decision condition ( $14/32 = 44\%$ ) than in the memory condition ( $4/32 = 12\%$ ).

These findings support the mere-presentation thesis. The likelihood of perceiving a two-digit number rather than a letter (13 vs. B) increases when the presence of a numeral is explicitly invoked via the possible response categories. As in a typical visual cognition study, the implicit choice in the memory condition was driven by participants’ reasonable expectations that the somewhat ambiguous stimulus

in the center of a series of letters is a letter as well: Here only 12% of participants saw the unexpected stimulus. However, when the two responses were presented side by side and participants had to choose explicitly between B and 13, almost half decided in favor of the unlikely stimulus—unlikely in light of the context. In other words, the request to consider two possible interpretations of an ambiguous symbol suffices to boost the likelihood of the unlikely interpretation.

## THE EFFECT OF MERE PRESENTATION IN A CLASSIC DEMONSTRATION OF THE BASE-RATE NEGLECT

We designed the next demonstration (Study 2) to examine the robustness of the results found in Study 1 in the context of category membership judgments—the very context in which classic studies of base-rate neglect such as the engineer-lawyer study (Tversky & Kahneman, 1974) were conducted.

To be able to create naturalistic stimuli (Koehler, 1996), we conducted a pilot study in which we asked 14 randomly chosen Technion students to complete a short questionnaire (Figure 9.2). Students' answers yielded 14 personality descriptions.

Respondents, students of industrial engineering and economics, saw photocopies of the completed (handwritten) questionnaires, excluding the first question (i.e., faculty), and we asked them to decide in which faculty each of the students described was studying. We compared two response mode conditions in a between-subject design. We asked participants in the open condition ( $n = 41$ ) to write down the name of the faculty they considered to be the right one. In the list condition ( $n = 43$ ),

Faculty [major] \_\_\_\_\_

Favorite leisure activity \_\_\_\_\_

Favorite food \_\_\_\_\_

Travel abroad \_\_\_\_\_

Workplace \_\_\_\_\_ # of hours per week \_\_\_\_\_

Hobbies \_\_\_\_\_

The prettiest building in the country \_\_\_\_\_

Important technological invention \_\_\_\_\_

Self-description \_\_\_\_\_

\_\_\_\_\_

**FIGURE 9.2** The self-description questionnaire used in Study 2.

TABLE 9.1 Study2 : The Objective Statistics and Main Results. The Left-hand columns present the categories (Technion's Faculties), the population statistics and the sample statistics. The right-hand columns present the choice proportion and estimated base rates in the two conditions (Open and List)

Faculty	Objective data				People's judgments			
	Population		Sample		Response prop.		Subj. base rate	
	Freq.	Prop.	Freq.	Prop.	Open	List	Open	List
Material eng.	152	0.02	0	0.00	0.01	0.02	0.02	0.02
Biology	218	0.02	1	0.07	0.02	0.03	0.03	0.04
Education	222	0.02	0	0.00	0.01	0.03	0.03	0.03
Mathematics	256	0.03	1	0.07	0.01	0.04	0.04	0.04
Food eng.	257	0.03	0	0.00	0.03	0.03	0.04	0.04
Chemistry	270	0.03	1	0.07	0.02	0.02	0.04	0.04
Agricultural eng.	289	0.03	1	0.07	0.03	0.04	0.04	0.04
Chemical eng.	341	0.04	0	0.00	0.02	0.04	0.04	0.04
Physics	354	0.04	0	0.00	0.04	0.04	0.04	0.04
Aerospace eng.	524	0.06	1	0.07	0.03	0.05	0.04	0.04
Medicine	534	0.06	0	0.00	0.01	0.05	0.07	0.06
Architecture	655	0.07	2	0.14	0.09	0.08	0.06	0.07
Computer science	733	0.08	0	0.00	0.16	0.11	0.10	0.10
Civil eng.	1008	0.11	2	0.14	0.07	0.07	0.08	0.07
Mechanical eng.	1081	0.11	1	0.07	0.16	0.13	0.10	0.09
Industrial eng.	1150	0.12	2	0.14	0.20	0.14	0.10	0.11
Electrical eng.	1406	0.15	2	0.14	0.10	0.09	0.13	0.12

we presented participants with a list of the Technion's 17 faculties, and we asked them to indicate their judgment by marking the faculty considered to be the right one.<sup>4</sup> We told participants that their goal was to maximize the number of accurate responses. To encourage accuracy, a bonus of 5 Shekels (\$1.70) for each correct response was promised to a participant who would be chosen at random. After concluding their judgments, all 84 participants received the same sheet on which we asked them to record their estimates of the base rates (proportions) of the Technion's 17 faculties.

How did the mere-presentation effect play out in this context previously shown to be conducive to base-rate neglect? The first five columns in Table 9.1 present the Technion's 17 faculties, the number of students enrolled in each faculty (in the relevant year), the proportion of students in each faculty from the total student population, and the frequency and proportion of the sample (the 14 students who

<sup>4</sup> Notice that in this setting, the implications of the mere-presentation hypothesis is identical to the list effect documented in Fischhoff, Slovic, and Lichtenstein (1978).

completed the self-description questionnaire) in each faculty. The last four columns present the main results: the proportion of the different responses (over the 14 descriptions) under the two experimental conditions and the average subjective base rate, respectively.

To measure the effect of base rates on students' responses, we transformed each faculty membership judgment into a quantitative response by relating it to the respective size of the faculty. For example, the response "biology" was coded as 218, the number of students enrolled at the biology faculty. The average of these numbers over the 14 responses was defined as the base-rate sensitivity (BRS) score. For example, if 7 responses involve a faculty with 600 students, and the other 7 responses involve a faculty with 1,000 students, the BRS score is  $(7/14)(600) + (7/14)(1,000) = 800$ . Thus, large BRS scores imply a tendency to select large, high base-rate faculties. The average score was 859 in the open condition but merely 754 in the list condition. The difference between the two conditions was highly significant,  $t(82) = 4.33, p < .0001$ .

A participant whose sensitivity to base rates could be described by the "probability matching" rule (see Birnbaum, 1983) was expected to have a BRS score in the range of 791 to 811. Thus, the results demonstrate that the actual sensitivity to base rates in the open condition exceeded that assuming a probability-matching strategy,  $t(41) = 3.17, p < .003$ . In the list condition, in contrast, people's sensitivity to base rates was lower than one would expect under a probability-matching strategy,  $t(43) = -2.4, p < .02$ . People's higher sensitivity in the open condition paid off: They were more accurate than students in the list condition, albeit that the difference in the average frequencies of accurate responses—3.1 in the open condition and 2.6 in the list condition—was only marginally significant,  $t(82) = 1.6, p = .11$ .

To examine whether participants may have rested their judgments on subjective base rates, which may not correspond exactly to the objective ones, we computed two correlations for each person. The first is the correlation between the frequencies of choices of the different faculties with the objective base rates. The second is the correlation between the choice frequencies with the assessed subjective base rates (i.e., the responses elicited in the second part of the study). The choice frequencies of the majority of the participants in both conditions correlated more strongly with the objective base rates than with the subjective ones. Across the two conditions, the proportion of participants whose choice frequencies were better predicted by the objective base rates (52/84) was significantly greater than .5 (sign test,  $p < .015$ ).

The results of Study 2 demonstrate that explicitly presenting possible response categories—Technion's faculties—affected the (implicit) use of base rates. That is, the mere-presentation effect is not restricted to the interpretation of ambiguous visual stimuli. In a context in which the response categories were not explicitly presented but respondents themselves generated the category (faculty) most likely in their view, judgments proved to be tuned to base rates. Indeed, the impact of base rate was stronger than would be expected if participants had resorted to a probability-matching response strategy. In contrast, the effect of base rates waned when all 17 response categories were laid out in front of people, and they had to judge which was the most likely one. With such imposition of the categories, the effect of base

rates was even smaller than expected assuming a probability-matching criterion. Indeed, these data do not even rule out the possibility that under these circumstances, people arrived at their judgments by neglecting base rates altogether.

## HOW THE MERE-PRESENTATION EFFECT FOSTERS BAYESIAN REASONING

One interpretation of the results we obtained in Studies 1 and 2 suggests that the presentation of possible responses (or response categories) has pernicious effects on people's inferences. On this view, base-rate information impacts open answers appropriately, whereas the mere-presentation effect in "constrained" answers compromises the role of base rates on people's reasoning. According to a second interpretation, however, the mere-presentation effect simply attenuates the impact of base-rate information. Thus, in a situation in which people tend to overweight base rates, the mere-presentation effect can also foster appropriate inferences. In the final study (Study 3), we demonstrated this potential of the mere-presentation effect. We made use of a traditional children's riddle, which reads as follows:

Danny broke his leg. When he got to the hospital the surgeon said: "I cannot operate on him. He is my son, although I am not his father." How can that be possible?

To appreciate how this riddle relates to the weighting of base-rate information, note that the vast majority of surgeons (at least in Israel at the time the study was run) are male. This riddle was popular because many people failed to see that the obvious answer is "the surgeon is Danny's mother." Thus, the difficulty of this riddle results from what can be described as a tendency to overweight base rates.<sup>5</sup>

A between-subject design included three experimental conditions and involved 71 industrial engineering students from the Technion. In the not-father condition, we presented 25 participants with the riddle as we described previously. A total of 16 participants in the not-mother condition read a version in which the words "not his father" were replaced with the words "not his mother." By comparing both conditions, one can investigate whether the failure to solve the riddle is consistent with the phenomenon of overweighting base rates. If so, one would expect a higher rate of correct (reasonable) responses in the not-mother condition than in the not-father condition. Finally, we presented 31 participants in the *p*[probability] (mother) condition with the standard riddle puzzle (as in the not-father condition), but we modified the question. We replaced the original question, "How can that be possible?" with the request to "Please assess the probability that the surgeon is Danny's mother."

<sup>5</sup> It can also be described as an example of stereotypical thinking and/or the usage of the representativeness heuristic. In this context, these terms have similar implications. See Beyth-Marom and Fischhoff (1983); Locksley, Borgida, Brekke, and Hepburn (1980); Locksley, Hepburn, and Ortiz (1982); and McCauley (1994).

TABLE 9.2 Frequencies of the Correct and Incorrect Answers in Study 3.

Condition	Task	Number of participants	Correct answers	Incorrect answers
Control	Explain how it can be possible	24	7	17
Not mother	Explain how it can be possible	16	16	0
$p(\text{mother})$	Estimate the probability that the surgeon is the boy's mother	31	25 (19 estimates of 100%, and 6 estimates between 75% and 99%)	6

How did the mere-presentation effect play out in this context that had previously been shown? The main findings are presented in Table 9.2. Each single participant (100%) in the not-mother condition arrived at the plausible explanation that the surgeon is the boy's father. In contrast, in the not-father condition, merely 29% (7 out of 24) of participants arrived at the explanation that the surgeon is the boy's mother. Other participants gave creative explanations such as "bad relationship between father and son," "stepfather," "adopted child," "close emotional feelings," and "sperm donation." The difference in the proportions of insightful answers in the not-mother and not-father conditions, respectively, was significant,  $t(38) = 6.08, p << .001$ .

In the  $p(\text{mother})$  condition, 19 (61%) out of 31 participants assessed the probability that the surgeon was the boy's mother as 1; an additional 6 students assessed the probability as greater than 0.75. Only 4 (12%) assessed the probability to be below 0.5. In a conservative comparison of the not-father condition and the  $p(\text{mother})$  condition, we focused on the proportion of "Mother with certainty" responses (i.e.,  $p(\text{mother}) = 1$ ). Again, the difference (between 61% to 29%) was significant,  $t(53) = 2.45, p << .01$ .

To conclude, this simple demonstration shows that the mere-presentation effect can foster good reasoning by channeling people's attention. When the most reasonable answer happens to be the low base-rate category, the mere presentation of this category (e.g., by asking participants to estimate its probability) suffices to move the large majority of the participants toward it.

## CONCLUSIONS

We conducted three simple studies that demonstrated the impact of merely mentioning response categories on the appreciation or lack thereof of base rates. The mere-presentation effect can help to explain why research on intuitive judgments under uncertainty and research on visual cognition arrived at opposite conclusions: insensitivity to prior probabilities and near-optimal statistical inferences in human perception and memory. When we asked our participants—without bringing into play a rare category or event—what they remembered, saw, or thought

they saw proved sensitive to base rates. This sensitivity, however, seemingly disappeared when the experimenter explicitly invoked unlikely categories by framing the response categories accordingly.

### *More on the Psychology of the Mere-Presentation Effect*

Objects continue to exist even when they are no longer visible. Becoming aware of this empirical regularity has been hailed as one key step infants take in their cognitive development. Based on observing his own children, Piaget (1936) concluded that “object permanence” was typically achieved at 8 to 9 months of age during the sensorimotor stage of cognitive development. Infants before this age—who do not have a clear sense of objects persisting when out of sight—would not grope for a teddy bear when suddenly the light went out. Of course, assuming the permanence of objects is not always correct. Sometimes objects stop existing when they stop being visible. Object permanence, however, is an adaptive assumption that renders navigating the world much simpler. Last, but not least, object permanence can be seen as a manifestation of the infant’s (growing) sensitivity to base rates.

Mortal humans who operate under the constraints of, for instance, limited time, information, energy, and computational capacity need to make myriad adaptive and simplifying assumptions about the world. For instance, in responding to a question or a problem, nobody can search and consider all possible options (e.g., response, response categories, or solutions), regardless of their a priori probability. In fact, there may not even be an optimal point at which search for further options ought to be stopped. If so, reasoners may decide to efficiently invest their resources by searching and evaluating predominantly those responses and response categories that are a priori likely. This reasonable assumption, however, can be suspended through a speaker’s mere presentation of unlikely responses and response categories. To communicate is to claim someone’s attention and hence to imply that the information communicated is relevant (Sperber & Wilson, 1986). Consequently, the hearer is likely to interpret the mere presentation of an unlikely category or event as a suggestion that the speaker considers it to be more relevant than may be expected on the basis of its prior probability. If the speaker is cooperative and aims to minimize the joint cognitive costs, he or she will not call on categories that are utterly unlikely and thus irrelevant.

The mere-presentation effect is the logical consequence of a cooperative venture called communication. Of course, the mere-presentation effect will not necessarily result in reasonable inference. When the mere presentation of the complete set of response categories is devoid of any information regarding their prior probabilities—Study 2 is an instance of such a scenario—the mere presentation can stand in the way of good performance. Finally, the magnitude of the mere-presentation effect is likely to be subject to factors such as experience. When people face the same choice problem over and over again, they may quickly learn that the presentation of response categories does not convey any extra and relevant information (see Betsch, Biel, Eddelbüttel, & Mock, 1998; Fielder, Brinkmann, Betsch, & Wild, 2000; Yechiam, Erev, & Barron, 2005).

### *Base-Rate Neglect, Conversational Maxims, and Intuition*

According to Kahneman (2003), the research that Tversky and Kahneman (1974) conducted was “guided by the idea that intuitive judgments occupy a position—perhaps corresponding to evolutionary history—between the automatic operations of perception and the deliberate operations of reasoning” (Kahneman, 2003, p. 450). In the terminology that permeates many of today’s discussions of how the mind reasons, Kahneman (2003) located flawed statistical intuitions and the cognitive machinery that drives them, that is, heuristics, in the first of two types of cognitive processes, which Stanovich and West (2000) labeled *System 1* and *System 2*. The operations of System 1 are typically characterized as fast, automatic, effortless, associative, and difficult to modify. In contrast, the operations of System 2 are depicted as slower, serial, effortful, and deliberately controlled. System 2 is involved in all voluntary actions—including overt expressions of the intuitive judgments that originated in System 1. Consequently, erroneous intuitive judgment such as base-rate neglect involves failures of both systems: System 1, which generated the misstep in the first place, and System 2, which failed to detect and correct it.

The utility of this and similar dichotomies has been hotly debated (e.g., Gigerenzer & Regier, 1996; Slovic, 1996). Our goal was not to rehash this debate. Rather, we believe that our few simple studies have produced a couple of interesting insights beyond the System 1 versus System 2 dichotomy. First, whether or not people take base rate into account is not merely the function of the cognitive system. It is also a function of the social environment: here, the provision of responses and response categories and the acceptance of specific social norms that guide communication. Second, what appears as inconsistent behavior—sensitivity to base rates in the open condition of Study 1 and little sensitivity in the list condition—can result from the same underlying cognitive process. The inconsistency is shaped by the combination of a response environment and a social environment that—unless told otherwise—is assumed to be cooperative. Third, it follows that investigations of intuitive statistical processes and their outcomes, may they be errors or correct responses, stand to benefit from an analysis of the social environment in which people act (see also Fiedler & Kareev, chap. 10, this volume). Last but not least, to the degree that statistical intuitions are guided by the interaction of heuristics and social environments, intuitions can be influenced by redesigning the latter (e.g., suspending maxims of conversation or changing the framing of a response).

## REFERENCES

- Ajzen, I. (1977). Intuitive theories of events and effects of base rate information on prediction. *Journal of Personality and Social Psychology*, *35*, 303–314.
- Anderson, J. R., & Milson, R. (1989). Human memory: An adaptive perspective. *Psychological Review*, *96*, 703–719.
- Anderson, J. R., & Schooler, L. J. (1991). Reflections of the environment in memory. *Psychological Science*, *2*, 396–408.
- Bar-Hillel, M. (1980). The base-rate fallacy in probability judgments. *Acta Psychologica*, *44*, 211–233.

- Betsch, T., Biel, G. M., Eddelbüttel, C., & Mock, A. (1998). Natural sampling and base-rate neglect. *European Journal of Social Psychology*, 28, 269–273.
- Beyth-Marom, R., & Fischhoff, B. (1983). Diagnosticity and pseudodiagnosticity. *Journal of Personality and Social Psychology*, 45, 1185–1195.
- Biederman, I., Mezzanotte, R. J., & Rabinowitz, J. C. (1982). Scene perception: Detecting and judging objects undergoing relational violations. *Cognitive Psychology*, 14, 143–177.
- Birnbaum, M. H. (1983). Base rates in Bayesian inference: Signal detection analysis of the cab problem. *American Journal of Psychology*, 96, 85–94.
- Bruner, J. S., & Minturn, A. L. (1955). Perceptual identification and perceptual organization. *Journal of General Psychology*, 53, 21–28.
- Cohen, L. J. (1981). Can human irrationality be experimentally demonstrated? *Behavioral and Brain Sciences*, 4, 317–370.
- Eisenberg, P., & Becker, C. (1982). Semantic context effects in visual word recognition, sentence processing and reading: Evidence for semantic strategies. *Journal of Experimental Psychology: Human Perception and Performance*, 8, 739–756.
- Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. *American Psychologist*, 49, 709–724.
- Erev, I., Leybman, I., & Hertwig, R. (2005). *Context, mere presentation and the impact of rare events*. Working paper, Technion, Haifa, Israel.
- Fiedler, K., Brinkmann, B., Betsch, T., & Wild, B. (2000). A sampling approach to biases in conditional probability judgments: Beyond base rate neglect and statistical format. *Journal of Experimental Psychology: General*, 129, 399–418.
- Fischhoff, B., Slovic, P., & Lichtenstein, S. (1978). Fault trees: Sensitivity of estimated failure probabilities to problem representations. *Journal of Experimental Psychology: Human Perception and Performance*, 4, 330–344.
- Foss, D. (1969). Decision processes during sentence comprehension: Effects of lexical item difficulty and position upon decision times. *Journal of Verbal Learning and Verbal Behavior*, 8, 457–462.
- Freeman, W. T. (1994). The generic viewpoint assumption in a framework for visual perception. *Nature*, 368, 542–545.
- Frost, R., & Katz, L. (1989). Orthographic depth and the interaction of visual and auditory processing in word recognition. *Memory and Cognition*, 17, 302–310.
- Gigerenzer, G. (1996). On narrow norms and vague heuristics: A reply to Kahneman and Tversky. *Psychological Review*, 103, 592–596.
- Gigerenzer, G., Hell, W., & Blank, H. (1988). Presentation and content: The use of base rates as a continuous variable. *Journal of Experimental Psychology: Human Perception and Performance*, 14, 513–525.
- Gigerenzer, G., & Regier, T. (1996). How do we tell an association from a rule? Comment on Sloman (1996). *Psychological Bulletin*, 119, 23–26.
- Gigerenzer, G., Todd, P. M., & the ABC Research Group. (1999). *Simple heuristics that make us smart*. New York: Oxford University Press.
- Gilovich, T., Griffin, D., & Kahneman, D. (2002). *Heuristics and biases: The psychology of intuitive judgment*. Cambridge, England: Cambridge University Press.
- Gould, S. J. (1992). *Bully for brontosaurus: Reflections in natural history*. New York: Norton.
- Grainger, J., & Segui, J. (1990). Neighborhood frequency effects in visual word recognition: A comparison of lexical and masked identification latencies. *Perception and Psychophysics*, 47, 191–198.
- Grice, H. P. (1975). Logic and conversation. In P. Cole & J. L. Morgan (Eds.), *Syntax and semantics: Vol. 3. Speech acts* (pp. 41–58). New York: Academic.
- Griffiths, T. L., & Tenenbaum, J. B. (2006). Optimal predictions in everyday cognition. *Psychological Science*, 17(9), 767–777.

- Hilton, D. J. (1995). The social context of reasoning: Conversational inference and rational judgment. *Psychological Bulletin*, *118*, 248–271.
- Howes, D. (1957). On the relation between the intelligibility and frequency of occurrence of English words. *Journal of the Acoustical Society of America*, *29*, 296–305.
- Kahneman, D. (2003). Maps of bounded rationality: Psychology for behavioral economics. *American Economic Review*, *93*, 1449–1475.
- Kahneman, D., Slovic, P., & Tversky, A. (Eds.). (1982). *Judgment under uncertainty: Heuristics and biases*. Cambridge, England: Cambridge University Press.
- Kahneman, D., & Tversky, A. (1973). On the psychology of prediction. *Psychological Review*, *80*, 237–251.
- Kahneman, D., & Tversky, A. (1996). On the reality of cognitive illusions. *Psychological Review*, *103*, 582–591.
- Knill, D. C., & Richards, W. A. (1996). *Perception as Bayesian inference*. Cambridge, England: Cambridge University Press.
- Koehler, J. J. (1996). The base rate fallacy reconsidered: Normative, descriptive and methodological challenges. *Behavioral and Brain Sciences*, *19*, 1–53.
- Körding, K., & Wolpert, D. M. (2004). Bayesian integration in sensorimotor learning. *Nature*, *427*, 244–247.
- Locksley, A., Borgida, E., Brekke, N., & Hepburn, C. (1980). Sex stereotypes and social judgment. *Journal of Personality and Social Psychology*, *39*, 821–831.
- Locksley, A., Hepburn, C., & Ortiz, V. (1982). Social stereotypes and judgments of individuals. *Journal of Experimental and Social Psychology*, *18*, 23–42.
- McCauley, C. (1994). Stereotypes as base rate predictions. Commentary on Koehler on base-rate. *Psychology*, *5*(05). Retrieved May 22, 2007, from <http://www.cogsci.ecs.soton.ac.uk/cgi/psyc/newpsy?5.05>
- Nisbett, R. E., & Ross, L. (1980). *Human inference: Strategies and shortcomings of social judgment*. Englewood Cliffs, NJ: Prentice-Hall.
- Piaget, J. (1936). La naissance de l'intelligence chez l'enfant. Geneva: Delachaux et Niestlé.
- Simon, H. A. (1991). Cognitive architectures and rational analysis: Comment. In K. van Lehn (Ed.), *Architectures for intelligence* (pp. 25–39). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.
- Simoncelli, E. P., & Olshausen, B. (2001). Natural image statistics and neural representation. *Annual Review of Neuroscience*, *24*, 1193–1216.
- Simons, D. J., & Levin, D. T. (1997). Failure to detect changes to attended objects in motion pictures. *Psychonomic Bulletin & Review*, *4*, 4501–4506.
- Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin*, *119*, 3–22.
- Sperber, D., & Wilson, D. (1986). *Relevance: Communication and cognition*. Cambridge, MA: Harvard University Press.
- Stanovich, K. E., & West, R. F. (2000). Individual differences in reasoning: Implications for the rationality debate. *Behavioral and Brain Sciences*, *23*, 645–665.
- Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristic & biases. *Science*, *185*, 1124–1131.
- Tversky, A., & Kahneman, D. (1982). Evidential impact of base rates. In D. Kahneman, P. Slovic, & A. Tversky (Eds.), *Judgment under uncertainty: Heuristic and biases* (pp. 153–160). Cambridge, England: Cambridge University Press.
- Yechiam, E., Barron, G., & Erev, I. (2005). The role of personal experience in contributing to different patterns of response to rare terrorist attacks. *Journal of Conflict Resolution*, *49*, 430–439.