Erschienen in: Behavioral and Brain Sciences ; 30 (2007), 3. - S. 263-264

Ecologically structured information: The power of pictures and other effective data presentations

DOI: 10.1017/S0140525X07001744

Wolfgang Gaissmaier,[a] Nils Straubinger,[a] and David C. Funder[a,b]

[a]*Center for Adaptive Behavior and Cognition, Max Planck Institute for Human Development, Lentzeallee 94, 14195 Berlin, Germany;* [b]*Department of Psychology, University of California, Riverside, CA 92521.*

gaissmaier@mpib-berlin.mpg.de
www.abc.mpib-berlin.mpg.de/users/gaissmaier
straubinger@mpib-berlin.mpg.de
www.abc.mpib-berlin.mpg.de./users/straubinger#funder@ucr.edu
www.rap.ucr.edu

Abstract: The general principle behind the effects of nested sets on the use of base rates, we believe, is that the mind is prepared to take in "ecologically structured information." Without any need to assume two cognitive systems, this principle explains how the proper use of base rates can be facilitated and also accounts for occasions when base rates are overused.

A picture speaks a thousand words. Barbey & Sloman (B&S) demonstrate this ancient principle with research showing how Euler circles efficiently convey complex information and clarify relationships among nested sets. Many other examples would be possible; tree diagrams, Venn diagrams, pie-charts, bar graphs, and other familiar data representations frequently appear in publications ranging from the most revered scientific journals to the pages of *USA Today*. As every successful speaker, writer, teacher, or advocate knows, some ways of presenting information are especially effective. The best way to teach an abstract concept may be via concrete examples. Certain pictures as well as natural frequencies appear to be especially useful ways to convey complex information. According to Pinker, "graphic formats present information in a way that is easier for people to perceive and reason about. However, it is hard to think of a theory or principle in contemporary cognitive science that explains why this should be so" (Pinker 1990, p. 73). We will introduce a concept that might help to answer this question, while also helping to explain why some diagrams support problem solving and others do not (see Larkin & Simon 1987).

The general principle is that the human perceptual and cognitive system uses certain kinds of information readily because it has impressive evolved and learned capacities for pattern recognition and automatic categorization. Hence, people can try to reason through an intricate system of interlocking sets to determine a probability, *or* they can look at certain diagrams and see the result literally at a glance. Similarly, natural frequencies and other well-chosen representations can vastly simplify problems and calculations that would otherwise be difficult, if not impossible. As Gigerenzer and Hoffrage (1995) observed, "Cognitive algorithms, Bayesian or otherwise, cannot be divorced from the information on which they operate and how that information is represented" (p. 701). What effective representations have in common is that they are *ecologically structured*, a term we derive from the concept of *ecological rationality*, which stresses the match between the human mind and the environment (Gigerenzer et al. 1999). Ecologically structured information can simplify apparently complex problems because it fulfills this match: It is presented in a manner that exploits human capacities to recognize relations in certain representations of complex problems (e.g., pictures and frequency counts). It is information received in the same way that people have evolved to receive information over the millennia: through vividly sensed images and experiences, and via specific instances, rather than abstract descriptions.

There is no need to posit two cognitive systems, as B&S do, to explain the advantages of ecologically structured information, and it is a serious mistake to describe the first of these systems as something "to overcome" (sect. 4) and the second as the ideal of sound reasoning. Ironically, if the pattern recognition capacities exploited by Euler circles were assigned to one of these putative systems, it would seem more reasonable to base them in the first, more perceptually based one. B&S nearly acknowledge this point when they conclude that "appropriate representations can induce people to substitute reasoning by rules with reasoning by association" (sect. 4, para. 2).

It is disappointing, therefore, that B&S rely on the traditional and simplistic dichotomy between "abstract reasoning = good" and "heuristics = bad." A vast amount of evidence demonstrates how heuristics can make us smart (e.g., Gigerenzer et al. 1999), and, in particular, how fast and frugal processes of the sort B&S would call "associative" are an important part of good performance. As Chase and Simon (1973) commented, concerning chess experts: "One key to understanding chess mastery, then, seems to lie in the immediate perceptual processing, for it is here that the game is structured" (p. 56). Other examples include recognizing a visual pattern (e.g., faces), listening to music, and acquiring a first language. Furthermore, thinking more "extensionally" may even lead one astray, depending on the environment (for an example from the domain of probability learning, see Gaissmaier et al. 2006).

B&S characterize prior research on the importance of "ask(ing) about uncertainty in a form that naïve respondents can understand" as "far too narrow" (sect. 1, para. 1). However, their article focuses on a single phenomenon, the underuse of base rates in probabilistic reasoning. Yet, early research on Bayesian inference observed the opposite phenomenon: *conservatism*, the overuse of base rates (e.g., Edwards 1968). A second phenomenon that can be seen as the opposite of base-rate neglect is described in the social psychological literature on *stereotypes*. Both base rates and stereotypes comprise beliefs about the prevalence of a characteristic in a population. But the current literature on base rates generally concludes that such beliefs are underused, whereas the stereotype literature almost uniformly concludes that they are *over*used (Funder 1996).

We believe that the concept of ecologically structured information can reconcile these two seemingly opposed phenomena. In studies of stereotypes, the belief about the population is vivid, accessible, and perhaps even emotionally tinged (e.g., the racial stereotype held by a bigot). The factual information opposed to that stereotype, by contrast, is typically rather pallid (e.g., crime rate statistics). In studies of base rates, the opposite pattern holds. The specific case information is vivid (e.g., a woman with a positive mammogram), while the base rate is pallid (e.g., the prevalence of disease in her demographic group; see Funder 1995; 1996, for a more complete analysis).

A picture speaks a thousand words, and ecologically structured information can communicate complex situations efficiently and clearly because it exploits elementary perceptual and cognitive capacities. The implications range far beyond the putatively uniform underuse of base rates upon which B&S focus so tightly; indeed, this principle can help to explain the apparently opposite phenomenon, the cases in which base rates (in a literature where they are labeled as stereotypes) are overused.