Rational Mind Designs

Research into the ecology of thought treads on contested terrain

By BRUCE BOWER

As a visiting scholar at Stanford University in 1990, Gerd Gigerenzer once joined in an animated lunchtime discussion with several colleagues about the implications of voluminous reported pitfalls in human reasoning. An economist tersely concluded the conversation with the zinger, "Look, either reasoning is rational or it's psychological."

That seemed to Gigerenzer, a psychologist fascinated by the history of statistical methods in science, a fair summary of how many social scientists treat the mind. Experimenters typically borrowed mathematical equations, or algorithms, from probability theory and treated them as "optimal" standards of rational decision making. According to this view, optimal judgments in uncertain situations rest on calculations that take all pertinent and available information into account. Human thinkers, with their often wayward psychological assumptions, could only flail at these ideals.

Beginning in the 1970s, researchers repeatedly found that volunteers grappling with various judgment tasks failed to reason according to the optimal mathematical formulas. That discrepancy led many psychologists to posit the existence of simple rules of thumb for making judgments that result in biased or irrational conclusions. They use the term "heuristics" for these rules. Heuristics have attracted blame for encouraging beliefs in astrology, faith healing, and UFOs, among other things.

For the past decade, in scientific papers and in lectures at U.S. and European universities, Gigerenzer has tried to yank heuristics off their throne. Although not the first critic of the idea that highly fallible assumptions rule human thought, he is perhaps the most aggressive, and he comes armed with alternative theories to explain human reasoning. As a result, the German scientist has attracted both ardent supporters and detractors, and his wake has roiled the waters of psychological research.

"We want to determine simple psychological principles that minds actually use and then examine how these principles exploit the structure of real-world environments," asserts Gigerenzer, director of the Center for Adaptive Behavior and Cognition at the Max Planck Institute for Psychological Research in Munich. "Such principles are rational, in the sense that they can be accurate and work quickly."

A tradition extending from 18th-century philosophers and mathematicians to modern social scientists assumes that rational, intelligent thinking conforms to the laws of probability theory and logic, Gigerenzer contends. This reflects a broader tendency on the part of behavioral researchers to think of the mind as a reflection of their tools, from statistical techniques to computer methods.

For instance, psychologists have for 35 years repeatedly assessed whether people make inferences according to Bayes' theorem, a mathematical formula that can be used to estimate an individual's expectation that a particular event will occur. Tests have consistently shown that people do not estimate probabilities according to Bayes' rule, typically because they fail to account for the base rates of events that they want to predict.

In one example, researchers ask volunteers to calculate the probability that a 40-year-old woman who has a positive mammography test actually has breast cancer. The correct answer involves not only the accuracy of the test, which gives a positive result in 80 percent of women with breast cancer, but also the base rate of the disease (1 percent among 40-year-old women) and the rate at which a mammography falsely reports breast cancer in healthy women.

Usually, volunteers asked to make this type of estimate focus on the first factor to the exclusion of the others and produce unduly high estimates, around 80 percent. Bayes' theorem, in which the base rate factors into a relatively complex calculation of the one-time probability of having breast cancer given a positive mammography, yields a prediction of 7.77 percent.

To explain such base-rate neglect, many researchers have invoked a judgment shortcut, or heuristic, known as representativeness, the tendency to assume that like goes with like. In the mammography problem, they propose, representativeness leads the volunteer to conclude that a positive test result and the presence of disease naturally go together. The ease of making that link fosters neglect of more complicated factors, such as base rate of the disease and the probability of false positives.

Gigerenzer, by contrast, views representativeness and other heuristics as fuzzy concepts that mask a fundamental point: The human mind did not evolve to perform statistical calculations that include percentages and other mathematical notions invented within the past 2 centuries. Humans and other animals instead rely on simple thinking mechanisms that operate on available information from their surroundings. At the core, these cognitive tools solve problems that have long proved crucial to survival and reproduction, such as distinguishing safe from poisonous foods, choosing a mate, and detecting cheaters in social exchanges (SN: 4/8/95, p. 220).

As humans evolved, the information available for making real-world decisions consisted of frequencies of experienced events, in Gigerenzer's view. In this way, for instance, a person could use knowledge about past successes in killing game to identify seasonally productive hunting sites or could consider the outcomes of prior encounters with a trading partner and his kin when negotiating a new deal with that person.

Bayesian problems, such as the mammography example, become easier to solve when the information is framed as frequencies of events rather than as percentages, argue Gigerenzer and Max Planck colleague Ulrich Hoffrage in the October 1995 PSYCHOLOGICAL REVIEW. In their study, 60 college students made correct inferences about half of the time on 15 such tasks—for example, estimating the probability of a man having AIDS if he tests positive for HIV—when accompanying information was expressed in frequencies, compared to about one-fifth of the time for information presented in percentages.

Consider the mammography problem stated in frequencies rather than probabilities. Gigerenzer and Hoffrage wrote that 10 out of every 1,000 women who participate in routine screenings have breast cancer at age 40; 8 out of 10 women with breast cancer will get a positive mammography; and 95 out of every 990 women without breast cancer will also get a positive mammography.

About half the time, volunteers correctly concluded that in a new sample of 40-year-old women who got a positive mammography, either 7 or 8 out of 100 actually had breast cancer. That answer comes from comparing the number of cases where breast cancer and a positive test result occur together (here, 8) with the total number of positive test results (8 plus 95, or 103). In this presentation of the problem, a participant can obtain the correct answer without explicitly evaluating the base rate.

Other volunteers were given the same problem expressed in percentages. Fewer than one in five volunteers accurately gauged the probability that a 40-year-old woman with a positive mammogram has breast cancer.

In an unpublished study of 48 Munich physicians given frequency and probability versions of the mammography problem and diagnostic conundrums concerning other potential diseases, Gigerenzer and Hoffrage again find that frequency formats yield many more correct inferences.

A number of prominent researchers warmly endorse Gigerenzer's approach. "Gerd is one of the most significant people now working in the field of judgment and decision making," asserts Lola L. Lopes of the University of Iowa in Iowa City. "He's taken an empirical stand against the view of some psychologists that people are pretty stupid."

Investigators who study heuristics and biases vigorously disagree with Lopes. In an article slated for publication this year in Psychological Review, Daniel Kahneman of Princeton University and Amos Tversky of Stanford University—who together launched this field of study about 25 years ago—reject the view that the mind handles frequencies better than single-case probabilities.

Judgments based on frequency information prove at least as susceptible to large errors as those rooted in single cases, Kahneman and Tversky argue. Studies indicate that individuals often find it easier to think about the probability of a single instance occurring, such as whether a stock will rise or an operation will be successful, than about frequencies of the same events, they contend (SN: 1/29/94, p. 72). Thus, they see Bayes' theorem as a mathematical expression of how people should think about events such as these.

While frequency information improves reasoning on Bayesian problems and undoubtedly other decisions as well, it clearly does not render judgment foolproof, Gigerenzer responds. Intelligent decisions get shaped by numerous, sometimes contradictory imperatives in the social world, in his opinion, such as the desire to maintain consistency, to revise thinking in the face of new information, to reach a swift verdict, or to make a judgment that can be justified afterwards.

Individuals do not usually possess the time, knowledge, or computational ability to reason "optimally," he holds.

"Fast and frugal" formulas for decision making offer a promising alternative, Gigerenzer contends. These guidelines make the most of limited knowledge and actually benefit from partial ignorance. In a computerized competition, a fast and frugal inferential technique achieves at least as much accuracy as judgments derived from each of several "optimality" formulas, and it does so with unmatched speed, according to Gigerenzer and Daniel G. Goldstein, also of the Max Planck Institute.

Gigerenzer and Goldstein have taken inspiration from a theory presented in 1956 by Herbert Simon of Carnegie Mellon University in Pittsburgh. Simon proposed that information-processing systems make decisions with the aid of "satisficing" formulas. Satisficing, a Scottish term that blends satisfying and sufficing, refers to the strategy of picking the first satisfactory option out of many choices instead of waiting to survey all possible alternatives.

For instance, a marriage-minded person makes the best practical choice by settling for the first romantic partner who displays qualities that he or she deems crucial, rather than searching indefinitely for Mr. or Ms. Perfect, Simon suggested.

The Max Planck researchers devised a satisficing rule along this line that they call "take the best."

In grappling with a quandary over two possible solutions to a problem, this model deals with pertinent bits of knowledge one at a time, moving from the best to the worst cues of those available. A decision gets made based on the first cues that tease out an answer.

A computer program employed a "take the best" strategy to guess the more populous site in pairs of 83 German cities. The program was set up to recognize a proportion of the cities, and it had access to various facts about them.

Each choice hinged, first, on the recognition of one city but not the other. A city that's recognized, and therefore presumably better known, may well contain more inhabitants than an unrecognized one, the scientists argue.

If neither or both cities were recognized, the model then considered a list of nine environmental cues of varying usefulness in discerning city size. Strong cues included being a state capital and having a major league soccer team; weaker ones included being located in Germany's industrial belt and serving as home to a university.

In a series of trials, the researchers programmed 500 simulated "take the best" subjects to recognize from 0 to 83 of the cities and to call upon various amounts of knowledge about the environmental cues.

The larger city was chosen half the time when no cities were recognized—a success rate no better than random guessing. Correct inferences climbed as subjects recognized more cities, reaching progressively higher levels with greater knowledge about the rest of the cues, but only up to a point. Maximum accuracy at picking larger cities—which peaked at three-quarters correct—occurred when simulated volunteers recognized only about half the cities presented to them, the researchers report in an upcoming Psychological Review. In that situation, they had the greatest number of pairs consisting of one recognized and one unfamiliar city.

Similar results emerged in a pilot study they conducted with 26 University of Chicago students. Volunteers more often made the correct choice from pairs of German cities, about half of which they did not recognize, than from pairs of U.S. cities, all of which they recognized.

Many decisions may operate according to this "less is more" process, as when someone judges whether or not a food merits a taste based on how familiar it appears, the scientists note. Many advertisers seem to realize that simply promoting recognition of a brand name, rather than a product's qualities, can effectively groom consumers' choices, they add.

"Take the best," with its heavy reliance on recognition, stacked up remarkably well against five statistical formulas that also guided simulated judgments about city sizes. These models accounted for all available information, each in its own fashion.

Three statistical models facilitated nearly the same proportions of correct city choices as "take the best" did; the remaining two approaches resulted in many more errors, the investigators assert. Since "take the best" required by far the briefest memory searches in reaching decisions, it wins the competition, Gigerenzer and Goldstein conclude. This result illustrates the value of devising bold, explicit predictions about how the mind operates, Gigerenzer adds.

Whether or not the fast and frugal upstart prevails, cognitive scientists must set their sights on specifying the ways in which people transform certain types of information into reliable knowledge about particular environments, Gigerenzer argues

"Much of psychology now consists of vague theories that don't spell out precise predictions," he contends. "Productive theories about the mind will have to risk being precise and opening themselves up to being disproved. Then we can begin to work out the ecology of rationality." □