Comment

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·1. STATISTICS

Maximization of expected utility (MEU) has so many important implications for statistics that an examination of one of its axiomatic foundations by as careful and original a scholar as Shafer is to be welcomed. He is critical of the axioms and I fear that many statisticians sensing this will draw the conclusion that Shafer has undermined the Savage axioms and that therefore MEU, the likelihood principle, and Bayesian statistics can be forgotten. They need an excuse to forget and get on with their unbiased estimates, tail-area significance tests, and confidence limits. It is therefore important to notice that Shafer's penetrating criticisms are not carried through to produce an alternative axiomatization, despite the hints to this effect at the beginning of the paper. We may hazard a guess that he feels that belief functions provide a possible substitute for MEU, but these, or any other system known to me, do not imply that currently popular methods of statistical analysis are sound. They are silent, for example, on the basic issue of the likelihood principle. In fact, he suggests that, where MEU is sensibly based on analogies with games of chance, it is sound and therefore the principle applies. So Bayesian statistics survives.

A second point to be recorded before passing to the central issue I wish to discuss, is my complete disagreement with Shafer's third paragraph. It was not until the late 1950s that Savage appreciated the Bayesian implications of what he had done: prior to that he had looked upon MEU as a foundation for sampling-theory statistics. Surely it is wrong to say that "the need for subjective judgment is now widely understood." Very few papers in statistical journals incorporate subjective views, although the number is increasing. Again it is wrong to say that MEU is obstructive; it is very constructive. Workers in artificial intelligence and expert systems are beginning to realize that an intelligent expert ought to think probabilistically.

2. PSYCHOLOGICAL EXPERIMENTS AND PARADOXES

Shafer makes much of the work of psychologists who have carried out experiments showing that people

do not maximize expected utility. It should be remembered that in almost all these experiments the subjects are students, required to assess probabilities when they have had no instruction in probability, or required to make decisions in trivial situations that are of no real importance to them. Is it really surprising that they are not very good at probability assessment or decision making? I draw quite a different conclusion from Shafer's. The bad nature of the inferences made and actions taken suggests that MEU has an enhanced status; for were it to be adopted, then there might well be a substantial improvement in decision making in fields where it really matters—and we all know that an improvement is needed. Had the psychologists' subjects been good maximizers the normative theory would have had little to offer.

Shafer also emphasizes the role of the paradoxes in MEU. He fails to point out that MEU can accommodate certain types of paradoxical behavior. Let us take Raiffa's (Figure 1) brilliant critique of Allais' paradox (Table 7). The only difference between Allais' original choice between f' and g' (at the left-hand edge of the tree in Figure 1) and Raiffa's suggested choice (after the white ball has been drawn) is, of course, the drawing of the white ball, the possible disappointment that it was not orange, and that $500,000 has passed one by. If the utility for Raiffa's choice reflects this disappointment then when we turn to f and g (where the underlined $500,000 is replaced by zero) no such disappointment is felt and the judgment may be different. I suspect that it often happens that when a person's behavior appears paradoxical it is because he is taking into account something that you have not considered and he has not mentioned. (In this example, the disappointment.) Readers may like to consider whether such an effect is really relevant in Allais' case. I think it is not.

3. NORMATIVE IDEAS

The relationship between normative and empirical concepts is a subtle one. I would like to argue by historical analogy. It is an analogy that I have used repeatedly before but it seems useful to me, and the critiques of it have not substantially changed its relevance for me to MEU. We have a normative theory for distances on the Earth's surface called (three-dimensional) geometry. This is basically due to Euclid. For many centuries this was little used because of the difficulties of measuring distances. Consider, for example, the great error that supreme navigator Colum-

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