NEWS AND VIEWS

Value of a Hypothesis

PROFESSOR P. A. STURROCK of Stanford University has published a paper on scientific inference in the *Astrophysical Journal* (182, 569; 1973). His object is to evaluate various hypotheses concerning a class of object in the light of several sets of observations upon members of the class, with special reference to applications of astrophysical interest.

Suppose we have a mixed bag of equal large numbers of black and white balls, and suppose two balls are abstracted at random. Consider the hypothesis, H , that these are two black balls. On the background knowledge supplied, the (prior) probability that H is valid is one-quarter. Suppose then that one ball of this pair is looked at and seen to be black; with this additional observational information, the (post) probability that H is valid (the "value" of the hypothesis) is one-half; if one of the pair is looked at and seen to be white, the post probability of H is zero. The theorem giving the general relation between post- and prior-probabilities is Bayes's rule.

In a broad sense, Sturrock produces a generalization of this rule. He illustrates his ideas using the case of pulsars, taking as hypotheses that a pulsar is (H_1) a rotating neutron star, (H_2) a pulsating white dwarf, (H_0) an object of some other sort. What he calls "items" in this example concern pulsed radio emission, range of periods, change of period, association with supernovae, photospheric radiation, power in the case of the Crab pulsar.

The novel feature of Sturrock's treatment is his concept of the "interface" between observation and theory. In any application, the interface consists of several "items". Each item consists of a set of statements about some feature, one and only one of which must be true: in the example the item about change of periods consists of the three statements: all pulsars slow down, all pulsars speed up, neither of these is true. Using the available particular observations, and whatever background information is relevant, the "observer" estimates a probability that each statement is true.

The hypotheses to be evaluated have to form a complete and mutually exclusive set. To them the "theorist" assigns prior probabilities; then he estimates the probability on each hypothesis that each statement in an item is true. The same background information is available to him, but he is supposed to know nothing about the observations special to the problem. Assuming the truth of any statement, and using Bayes's rule, the theorist can then evaluate the (post) probability for each hypothesis. Combining this with the observer's estimate of the probability of each statement, the theorist then obtains the post probability of the hypothesis so far as one entire item is concerned. Sturrock finally gives the (non-trivial) combination of such results for any number of items.

Contact between observation and theory occurs only at the interface of statements. The observer estimates the probabilities that certain fairly general statements are valid in the light of the observational material; as Sturrock says, these estimates must be without theoretical bias. The theorist estimates the probabilities that his hypotheses are valid if one or another of the statements is valid; these estimates must be without observational

bias. Then the two sets of probabilities meet at the interface and produce the evaluations. This formalizes the procedure presumably followed, implicitly and unsystematically, in observational science in general.

In order to follow Sturrock's procedure, the reader needs to study his example on pulsars. He gives it for illustration only, but it is remarkable that some four years ago he got for the post probabilities based on all items: for neutron star 0.995, white dwarf 10^{-8} , some other object 0.005.

Sturrock is disarmingly candid about the several basic difficulties of such work which he explicitly refrains from examining in his paper. In particular, there are two inter-related weaknesses; the need for the "null" or "ignorance" hypothesis (H_0 in the example) and the subjective character of the assigned probabilities.

Significance may be placed upon the probabilities of the other hypotheses relative to the null hypothesis only on the subjective impression that one has been generous to the null hypothesis. As regards the probabilities of the other hypotheses relative to each other, however, under certain circumstances it may be possible to demonstrate that these are insensitive assumptions about the null hypothesis.

In its present formulation, Sturrock's work would apply only to the standard detective-story type of problem where the observer (policeman) and the theorist ("Poirot") have to choose one of several given suspects or the possibility of an "outside job". The detective story-teller's aim is to keep all subjective probabilities about equal until some crucial item comes along. One thing to be learned from Sturrock, however, is that, even if each available item is inconclusive in itself, the resultant effect of several items may give almost completely convincing support for one solution. This would be expected, but it is highly interesting to see Sturrock's quantitative illustration. But again there is still the subjective element, well recognized in detective fiction at the stage when "Poirot" knows the culprit but still has no case for a court of law.

Most astrophysical problems for most of the time are not detective problems of this sort, and the scope for the full application of such work is obviously restricted. Nevertheless it may have value in several ways: first, it may help to classify the activities of various investigators, each of whom may be said to be trying to evaluate any one of Sturrock's probabilities in regard to some current problem, and so to clarify the purposes of the investigations; second, it should show which items of observation might be expected to have most significance for the solution of the problem; third, in a large class of problems, it seems to be the aim ultimately to reach a stage when Sturrock's type of evaluation is needed—implicitly or explicitly—and it may expedite a decision to make it explicit. On the other hand, there are large parts of astrophysics where it would probably be an arid proceeding to try and impose such an analysis. In any event, Sturrock has made a valiant effort to bring order into the haphazard procedures of most astrophysicists.

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