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BAYESIANISM: SCIENCE OR PSEUDOSCIENCE?

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ABSTRACT

This is a criticism of Bayesianism, the opinion that all probabilities are a matter of opinion, hence beyond objective tests. It is shown that the mathematical concept of a probability function makes no room for a person, and that in physics, chemistry and biology probabilities are objective quantities subject to calculation and measurement. It is also shown that the use of subjective probabilities in medicine and criminology is bound to lead to either nonsense or injustice. The upshot is that only the realistic interpretation of probability, as the quantitation of objective possibility, is legitimate.

Key words: Bayesianism, frequency, objectivism, probability, subjectivism

> A learned fool is even more foolish than an ignorant one.
> (Molière, *Les femmes savantes*)

Bayesianism is the doctrine according to which probabilities are a matter of opinion because they would only measure the strength of our beliefs (de Finetti, 1972; Jeffreys, 1975; Keynes, 1957; Savage, 1954). According to this view, all and only propositions (or statements) qualify as more or less probable. Moreover, my assessment of the probability of a given proposition is likely to differ from yours and, because probability, like beauty, is in the eye of the beholder, there is no way to tell which if any of these conflicting opinions is right. My goal in this paper is to examine Bayesianism to find out whether it is scientific and thus deserves the attention of legal experts, medical doctors, and other specialists. To perform this task I will draw heavily on some previous work of mine (Bunge, 1951, 1976, 1981, 1988, 2003, 2006).

BEWARE ORDINARY LANGUAGE

Bayesianism is quite popular, partly because of the confusion of the word 'probability' in its mathematical sense with its ordinary-language homologue, which covers such different concepts as those of frequency, likelihood, and plausibility or verisimilitude. More than two centuries ago, Bayesianism

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penetrated the law, where it is sometimes referred to sarcastically as 'trial by numbers'.

Thus, according to one juror in almost any trial, the defendant is 'probably' innocent, whereas another juror swears that the same individual is 'probably' guilty. Moreover, while a judge may state confidently that a given criminal is 'probably' a recidivist, he may decide that another individual will 'probably' desist from a career in crime. Not surprisingly, in Texas the law requires the jurors to consider 'whether there is a probability that the defendant would commit criminal acts of violence that would constitute a threat to society'. Regrettably, the jurors are not instructed on how to evaluate such a 'probability': presumably, they are expected to use cowboy's horse commonsense to decide on a person's life.

What to do in the face of such uncertainties? A scientist would presumably recommend reviewing all the evidence of the case, summoning further experts, or perhaps checking the circumstances of the jurors to make sure that they have been neither bribed nor intimidated. Not so a learned jurist of the Bayesian persuasion: he (or she) will be likely (not 'probably'!) to suggest applying Condorcet's famous Jury Theorem: increase the number of jurors regardless of their qualifications and the quality of the extant evidence.

But of course the jurist sold on Bayesianism is unlikely to exhibit any empirical evidence for or against the truth of the said theorem, if only because the very concept of truth does not occur in Bayesianism, which is radically subjectivist, hence relativist. So, the jurist practices the law based on no evidence whatsoever. The nose has replaced the frontal cortex, and consequently the kangaroo court has replaced the legitimate court of law.

The conspicuous absence of the concepts of objective truth and evidence should suffice to alert the skeptical jurist to the dangers of Bayesianism. Indeed, the very first step in any legitimate judicial process is to try and find out the truth of the matter: to establish whether or not the facts in question have occurred, and whether or not the relevant statements referring to them fit the said facts, that is, are true at least to a first approximation. In the law, just as in science and in technology, we seek *episteme* (science) rather than *doxa* (opinion).

Moreover, in the field of human action there are certainly plenty of accidents, but there is no irreducible chance or randomness of the kind we meet in quantum mechanics, quantum chemistry, molecular biology, or genetics. In particular, the concept of chance or randomness has no place in criminology. People either steal or they don't, murder or they don't, and so on. There is nothing random about crime, because every criminal action is the last link in one or more causal chains. Now, it so happens that only states and changes of state (events) are assigned probabilities in the sciences. Moreover, such probabilities can be calculated unambiguously and measured accurately rather than being assigned arbitrarily.

For example, physicists calculate and measure the probability that a given incoming particle will be deflected by a target atomic nucleus within a given solid angle during one time unit. It is true that probability is also used in the biosocial sciences, such as epidemiology, and in the social sciences, such as sociology. Thus, for instance, one can legitimately speak of contagion probability, and of the probability of someone climbing up or down a social hierarchy on reasons other than merit. But in these cases, just as in the natural sciences, the probabilities in question are objective, not subjective.

In sum, the interpretation of probability employed in science is not subjective or Bayesian, but objective or realist. It is regarded as a measure of objective possibility. Nobody in science, except for the psychologists and sociologists who study belief, is interested in mere opinions about facts, and nobody is bold enough to assign probabilities to either scientific data or scientific hypotheses, the way Bayesians do. To be sure, one often indulges in subjective estimates (or eye-balling) of objective probabilities, just as one may perform intuitive estimates of anything else. However, such estimates are extratheoretical, provisional, and never intended to replace well-founded calculations and accurate measurements.

LEARNED IGNORANCE

The subjectivist interpretation of probability is inconsistent with the realism prevailing in science and technology. It is generally known as Bayesianism because of its heavy reliance on a certain interpretation of Bayes' theorem, which is a legitimate piece of basic mathematics, which does not refer to the real world. (The theorem in question relates the probability of item *a* given item *b*, to the 'inverse' probability of *b* given *a*.)

Bayesianism holds that (a) probabilities are properties of beliefs, propositions, or statements, rather than of facts of a certain kind; and (b) more precisely, 'probability measures the confidence that a particular individual has in the truth of a particular proposition, for example, the proposition that it will rain tomorrow' (Savage, 1954: p. 3).

For all its popularity among philosophers, and its throng of faithful among statisticians, Bayesianism is a minority view in the scientific community. The reason scientists have to avoid Bayesianism is that, because it is subjectivist, it invites arbitrary probability assignments to anything — hardly a scientific procedure. Besides, as Venn (1962) noted more than a century ago, any strong emotion or passion will influence our estimates of the likelihood of events. For instance, we tend to overrate the likelihood of pleasurable events, such as lottery winnings, while underrating the likelihood of disagreeable events, such as traffic fatalities.

For all its popularity among philosophers and statisticians, Bayesianism is wrong-headed because it originates in an ontological dogma and in two major confusions. The dogma in question is classical determinism or causalism, so brilliantly described by Laplace two centuries ago, and certainly justifiable at his time. This is the belief that everything happens according to laws that, such as

Newton's, have a broad causal domain. If this were true, chance would indeed be but a name for our ignorance of causes, so that an omniscient being would be able to dispense with the concept of chance.

However, the basic laws of quantum theory and population genetics are probabilistic, and they do not derive from causal laws. Rather on the contrary, many a macro-law is a law of averages, and it can thus be deduced from probabilistic micro-laws. The second law of classical thermodynamics is a case in point; another famous example is the law of the exponential decay of a sample of radioactive material. So much for the error at the root of the subjectivist interpretation of probability. Let us now turn to the accompanying confusions.

A first confusion is that between propositions (or statements) and their referents. Suppose, for example, that V designates a random variable, such as the number of points scored in a die throw. Further, call $Pr(V = v)$ the probability that, on a given occasion, the variable V takes on the particular value v, such as the ace. The proposition '$Pr(V = v) = 1/6$' involves the proposition '$V = v$', but it should not be read as the probability of this proposition, since such an expression makes no clear sense. The gambler knows that the proposition '$Pr(V = \text{ace}) = 1/6$' states the probability of the fact of getting an ace when throwing a well-shaken dice cup. He is interested in the outcome of a real process characterized by objective disorder — the one resulting from vigorous and repeated shaking.

A second major source of Bayesianism is the confusion of objective chance with subjective uncertainty. This is a conflation between an ontological category and a psychological (and epistemological) one. To be sure, this confusion is rather natural, because objective indeterminacy implies subjective uncertainty — though not conversely. For example, while shaking vigorously a dice-cup, every one of the six sides of a die acquires the same chance of coming up when the die is cast. However, once the die is cast, determinacy has replaced indeterminacy, whereas subjective uncertainty remains as long as we do not look at the die. The Bayesian has no right to say that the probability that he will *see* an ace is 1/6, because the random process that culminated in this fact is over: *alea jacta est*. If an ace is what came up, the gambler is allowed to look, and his eyesight is normal, he *will* see an ace regardless of his expectations.

Moerover, the gambler's mental process is quite different from the random physical process that he triggers when rolling dice; so much so, that the gambler who ignores the laws of chance is bound to form irrational expectations, such as the popular gambler's fallacy ('The next throw must be an ace, since no ace occurred in the last five throws'). That is, our expectations may not mirror objective chance. If they did, neither casinos nor lotteries would be profitable. The only way to defeat chance is by cheating.

UNCERTAINTY AND PROBABILITY

Though incompetent to form rational expectations, the calculus of probability includes an *objective* measure of uncertainty. This is the variance (or dispersion, or spread) of a distribution such as a scatter plot. The variance, or square of the standard deviation σ, is a function of probability. In the simplest case of a binomial distribution, when the random variable assumes only the values 0 or 1 with corresponding probabilities p and $1 - p$, the variance is $\sigma^2 = p - p^2$. The shape of this curve is an inverted-U around the point $p = 1/2$; it vanishes at the extremes $p = 0$ and $p = 1$, and attains its maximum at the mid-point $p = 1/2$. This particular maximal uncertainty value is 1/4, whereas the corresponding improbability is $1 - p = 1 - 1/2 = 1/2$ (see, e.g., Feller, 1968: p. 230).

In short, given a probability distribution, one can calculate, among other statistics, the objective uncertainty (or indeterminacy) associated with it. This is an objective feature of the given population and the corresponding data, not of anyone's beliefs. Whether a given human subject will 'feel' or intuit the same subjective uncertainty, is a matter for experimental psychologists to find out. In any event, the upshot is clear: improbability, or $1 - p$, is not an adequate measure of uncertainty, whether objective or subjective.

We all know that predictions of certain kinds, such as those of hotly contested elections, are dicey. However, they should not be cast in probabilistic terms if they concern non-random events, such as collisions between tectonic plates, rainfalls, crops, the onset of sickness, the outcomes of political elections, or Armageddon. True, the weather forecasts reported in the media are usually cast in probabilistic terms. But this practice is wrong, because such forecasts are not calculated with the help of probabilistic meteorology — which so far is only a research project. The meteorological 'probabilities' in question are mere likelihoods (in the non-technical sense of the word), because they are estimated on the strength of weather records, satellite images, and measurements of the velocity of displacements of the major 'weather-makers' (see Bunge, 2003 for the differences between likelihood, plausibility, and probability).

As for election outcomes, the reason that they should not be cast in probabilistic terms is that such results depend on the candidates' track record and promises, as well as on carefully planned, smartly-advertised, and well-financed campaigns — or even on the complicity of electoral officers and judges. Yet, two prominent academics (Kaplan and Barnett, 2003) have proposed a Bayesian model for estimating the probability of winning the United States presidency. It had certainly been noted that the American political process was being privatized, but no one had suggested before that the gaming industry was about to take it over.

THE CONFUSIONS OF BAYESIANISM

So far I have argued that the idea of assigning probabilities to statements originates in both outdated metaphysics and sheer confusion. However, I have yet to prove that the idea is wrong. There are several reasons why it is mistaken. One of them is that the formula 'The probability of statement *s* equals *p*', or '$Pr(s) = p$' for short, does not include a variable denoting a person — which is not surprising since the calculus of probability is not a branch of cognitive psychology. And yet Bayesians call themselves 'personalists'.

Another objection is that propositions neither pop up nor vanish at random. Of course, one could think of picking a proposition at random from a set of propositions, and ask what its probability is. But this would be just a parlor game, unrelated to the scientific search for truth. If the expression in question is intended to mean that the proposition of interest has a truth value lying between 0 (total falsity) and 1 (complete truth), then this can and must be said clearly, namely thus: 'The proposition is partially true'. For example, '$\pi = 3$' and 'Our planet is spherical' are approximately true propositions, whereas their negations are completely true (Bunge, 2003).

However, partial truths are not probabilities. To make this point, the following counter-example should suffice: the proposition 'George W. Bush is a forthright American' is half-true, since it is true that the said individual is an American, but false that he always tells the truth. Yet, if partial truth is equated with probability, we must regard the given proposition as false, since its probability equals the product of the probabilities of the two constituent propositions, one of which is 1 and the other 0.

All the calculi cast in terms of probabilities of propositions, such as those of Reichenbach (1949), Carnap (1950), Popper (1959b), and their followers, are wrong because (a) the concept of truth is more basic than that of probability, and (b) propositions, unlike random events, cannot be assigned probabilities except arbirarily (see also Bunge, 1963).

Let us next examine the Bayesian claim that probabilities measure credences, or degrees of rational belief. This is an empirical question, hence it cannot be settled *a priori* — the way subjectivists claim. Let us therefore ask cognitive psychologists whether people actually think in accordance with the said calculus when reasoning about uncertain matters. The many experiments of Daniel Kahneman and his students have conclusively shown that our subjective judgments of likelihood and plausibility (or verisimilitude) are often incorrect, and do not meet the axioms of the probability calculus (Kahneman *et al.*, 1982). To begin with, when considering a branching process, such as a decision tree, there are rarely enough data to include all the possible forks — a condition for ensuring that the sum of the probabilities over all the branches equals unity. Next, we tend to exaggerate the probabilities of certain unlikely events, such as that of contracting the bird flu. Fear, greed, wishful thinking, superstition, strong emotion, and association with pleasurable or painful experiences, are among the factors that distort our judgments of the objective likelihood and actual frequency of an event. In short, Perceived likelihood ≠ Objective likelihood. In other words, Probability ≠ Degree of rational belief.

Furthermore, beliefs do not satisfy the probability laws. One of these laws is '$Pr(A \& B) \leq Pr(A), Pr(B)$'. If we set A = 'Liberty is good', and B = 'Equality is good', then libertarians swear by A, egalitarians by B, and neither by both. In my opinion, neither liberty nor equality is by itself a social good, or even viable, because liberty is impossible among the unequal, and forced equality muffles liberty. But it is arguable that the combination of liberty with equality is both viable and good. So, if we had a plausible logic of beliefs, I would state the dual of the probabilistic inequality, namely, $D(A \& B) \geq D(A), D(B)$, where D would stand for a strength of belief function.

In sum, the probability calculus is not a true theory of beliefs. Hence, Bayesianism is not a true account of beliefs, which is not surprising, because the truth in question is objective, something Bayesians do not much care for.

BAYES' THEOREM: CORRECT AND INCORRECT USES

Inductiver logicians, from Carnap (1950) onwards, have claimed that probability exactifies the vague notion of inductive (or empirical) support. This is essentially the idea that the conditional probability of hypothesis h given evidence e, or $Pr(h/e)$ for short, must differ from the probability $Pr(h)$ assessed before having produced e. But how do we assess the prior $Pr(h)$ except by fiat, hence how do we compare the prior probability $Pr(h)$ to the posterior probability $Pr(h/e)$? And what does '$Pr(h)$' mean anyway? It cannot mean 'plausibility' or 'verisimilitude', because this is relative to context, and it is hardly a numerical concept.

Let us face it: the so-called probabilities of hypotheses are opinions on opinions — doxa squared. Yet, Bayesians claim that they hold the key to understanding the advancement of scientific knowledge, from data to hypotheses and back. For instance, hypothesis h would be confirmed by evidence e if $Pr(h/e) > Pr(h)$. However, to my knowledge no one has been foolhardy enough to assign probabilities to any scientific laws, such as those of classical, relativistic, or quantum mechanics.

Let us contrast the scientific and the Bayesian uses of Bayes' theorem, the centerpiece of both Bayesian statistics and inductive logic. As will be recalled, that theorem, which is a correct piece of neutral mathematics, reads thus: $Pr(A/B) = Pr(B/A)\ Pr(A)/Pr(B)$. Let A and B denote two states of a concrete system, $Pr(B/A)$ the probability that, given that the system is in state A, it will go over to state B, and $Pr(A/B)$ the probability of the reverse process. According to non-Bayesians, at least two conditions must be met to introduce these conditional probabilities into Bayes' theorem: (a) both processes, $A \rightarrow B$ and $B \rightarrow A$, must be really possible, that is, they must be consistent with the pertinent objective laws; and (b) both processes must be random, that is, describable by a probabilistic model. Yet, Bayesians require neither condition. Therefore, as noted above, a Bayesian might be tempted to assign a non-vanishing probability to the impossible transition Dead → Alive. Furthermore, since the definition of $Pr(A/B)$ involves $Pr(A\&B)$, the Bayesian must admit that it is possible to be alive and dead at the same time. (Incidentally, this counterexample confutes the opinion that the transition probabilities calculated in quantum mechanics and other theories are conditional probabilities.)

A third condition for the legitimate application of Bayes' theorem is that three out of the four probabilities occurring in the theorem be known. When the prior probabilities $Pr(A)$ and $Pr(B)$ are unknown, as is the case when A = hypothesis h, and B = evidence e, writing $Pr(h/e)$ and $Pr(e/h)$ in terms of them, amounts to scribbling squiggles. And yet this is how Bayes' theorem is used in both Bayesian statistics and inductive logic. For instance, when estimating the probability of an event, or the plausibility of a proposition the Bayesian consults a panel of experts. That is, he seeks 'a consensus view of informed opinion', just the way one proceeds in everyday life with regard to everyday matters — with the difference that the Bayesian assigns numbers to strengths of belief (see, e.g., Press, 1989). True, self-styled objectivist Bayesians equate $Pr(h/e)$ to the corresponding frequency — for example, that a positive clinical test is evidence for a certain sickness; but they make up the other 'probabilities', in particular $Pr(h)$. Besides, in equating certain probabilities with frequencies, they violate the credo that probabilities are credences.

PRIOR PROBABILITIES ARE INSCRUTABLE

The occurrence of unknown prior probabilities, that must be stipulated arbitrarily, does not worry the Bayesian anymore than God's inscrutable designs worry the theologian. Thus Lindley (1976), one of the leaders of the Bayesian school, holds that this difficulty has been 'grossly exaggerated'. And he adds: 'I am often asked if the [Bayesian] method gives the *right* answer: or, more particularly, how do you know if you have got the *right* prior [probability]. My reply is that I don't know what is meant by 'right' in this context. The Bayesian theory is about *coherence,* not about right or wrong' (*op. cit*: p. 359). Thus the Bayesian, along with the philosopher who only cares about the cogency of arguments, fits in with the reasoning madman.

From a methodological viewpoint, the entire debate over subjective versus objective probabilities boils down to the following argument, the second premise of which was unwittingly supplied by no less than the statistician who started the contemporary phase of Bayesianism (de Finetti, 1962: p. 360):

If a hypothesis is untestable, it is not scientific.

Now, the Bayesians 'maintain that a probability evaluation, being but a measure of someone's belief, is not susceptible of being proved or disproved by the facts'.

Therefore, Bayesianism is unscientific.

This should settle the question for scientific realists. but these are still a minority among philosophers, so that Bayesianism may survive for a while, along with mind-body dualism, many-worlds metaphysics, and other philosophical extravagances. Meanwhile let us hope that it will be gradually discontinued in the law, medicine, seismic engineering, policy-making, and other fields where lives are at stake.

BAYESIANISM CAN BE DISASTROUS

Unsurprisingly, Bayesianism can have catastrophic practical consequences. Let us note three examples. The first concerns experimental design, which is crucial in determining the efficacy and safety of drugs, agricultural techniques, social programs, and more. Since about 1930, it has been standard practice in the biosciences and the social sciences to randomize both the experimental and the control groups (see Fisher, 1951). Now, Bayesians do not practice randomization because they have no use for the concept of objective randomness: for them, chance is only in the eyes of the beholder. Hence, if the U.S. Food and Drug Administration and the various agricultural experimental and forestry stations were ever to be dominated by Bayesians, they would become public perils rather than guardians of public health.

Another example of the high risk incurred by Bayesians is the 'probabilistic' risk assessment used by the NASA managers to estimate the risk of manned space flights in the cases of the ill-fated space shuttles Challenger and Columbia. I submit that juggling with probabilities is inappropriate in the case of the failure of components of a machine, because this is a causal chain, not a random one — such as a Markov chain, every link of which has an objective probability that depends only upon the preceding link.

In general, disasters — from computer crash to early death, from bankruptcy to biospecies extinction, from hurricane to earthquake, from epidemics to war, and from bank robbery to murder — are nonrandom events, hence unaccountable in probabilistic terms. True, the extinction of species and the decline of ecosystems have often been modeled assuming that the events in question are random. But they are not, for actually the dominant ecological variables are nonrandom. We can think of rainfall, species rarity, body size, and the presence or absence of carnivores, keystone species (like starfish), as well as of aggressive invaders (such as elephant grass). Hence those stochastic models are unrealistic, and therefore they are misleading tools for designing environmental protection policies.

Recent experiments have shown that ecosystems decline faster than expected if they were to be happening by chance (Raffaelli, 2004). The reason is that, when removing species (or rather populations) at random, one treats them all equally, while actually some are more important than others. In any event, the experiments in question have falsified the probabilistic models of ecosystem sustainability. Obviously, this result should have dramatic consequences for environmental policies as well as for theoretical ecology. The moral is that probability without randomness can be deleterious to the environment.

Our third example will be the Bayesian approach to medical diagnosis and prognosis, adopted by Wulff (1981) and many other medical theorists. Since we know that the disease-symptom association is causal rather than random, there is no reason to expect that their probabilities exist and are related in the way Bayes' theorem stipulates. Unsurprisingly, the available statistics concerning cancer detection fail to satisfy Bayes' formula (Eddy, 1982). In sum, Bayesian medicine is unrealistic, and therefore unreliable, because it does not match the actual diagnostic process, which involves plausibility judgments based on anatomy and physiology, and to a lesser extent also on epidemiology.

TRIAL BY NUMBERS

Phrases such as 'the probability of guilt', 'balance of probabilities', and 'the probability of a just verdict', have been rather common in modern legal jargon. This may be due in part to the healthy influence of the skepticism that accompanies British (particularly Scottish) empiricism. I submit that the phrases in question are legitimate as long as the work 'probability' is taken in its ordinary-language sense, but that they invite trouble when it is interpreted as designating the concept elucidated by the mathematical theory of probability. (The same holds for the French and German equivalents of 'probable'.) I suggest that, to avoid trouble, one should speak of likelihood in the case of facts, and of plausibility in that of hypotheses. Let us take a closer look at this question, which is not merely a terminological one.

Consider the sentence 'He probably committed the crime'. I claim that the adverb should not be taken literally, in the sense of the probability calculus, because crimes are either committed or not committed: they are outcomes of deliberate actions, not of random processes. Hence, the sentence in question should be replaced with this one: 'It is likely that he committed the crime'. And of course no attempt should be made to quantify this likelihood. The most we can do is to add the statistical information that crimes of the given type occur with such and such frequency among persons of the same characteristics. Much the same holds of course for sentences of the form 'Given (or in the light of) that evidence, it is probable that the defendant committed the crime'. Just say that the evidence in question supports the guess (or hypothesis) that the individual in question is guilty. And do not attempt to assign a number to the weight of the evidence, because the scales of justice do not weigh evidence. To write formulas such as '$Pr(h/e) = 0.75$' is at best a waste of time.

What can sometimes be done is to measure the relative frequency of actions of a certain type. For example, it is known that the frequency of criminal offences is age-dependent. This distribution increases from childhood on, peaks at about 17 years, and then declines down to a plateau. The causes are multiple, among them poverty, the greater freedom and more intense urges of adolescents, jointly with the comparatively slow maturation of the prefrontal cortex (see, e.g., Hawkins, 1996; Lahey *et al.*, 2003; Maguire *et a*l., 1994; Robinson, 2004; Wilkström and Sampson, 2006). However, such data cannot be used to construct the prior probability that an adolescent will commit a crime. Likewise, the fact that nearly half of the world population is Asian is no ground for expecting that the probability than an Icelandic woman will give birth to an Asian child is one-half. Statistics give us collective regularities, not individual dispositions.

Interestingly, while statistics cannot help diagnose crime, they can shed some light on the fairness of a system of criminal justice. For instance, it is well known that, in the U.S., twelve African Americans for every White person are convicted for capital offenses. In other words, African Americans are 12 times more likely to be condemned than their White counterparts. It has been argued that the reason for this glaring asymmetry is not that African Americans are worse than Whites, but that they cannot afford to retain competent legal counsel. In other words, in a corrupt society, justice is a market value rather than a moral value.

SUBJECTIVISM: THE MOTHER OF ALL PSEUDOSCIENCE

The unrealistic nature of the Bayesian approach is of course part of its subjectivism. But Bayesians believe that this is a shining virtue rather than a fatal flaw. Thus, Howson and Urbach (1989: p. 288) state that '[s]cience is objective to the extent that the procudures of inference in science are. But if those procedures reflect purely personal beliefs to a greater or lesser extent, [...] then the inductive conclusions thus generated will also reflect those purely personal opinions'. This statement contains three elementary mistakes. The first is the quaint idea that objectivity resides in inference rather than in reference. (Inferences are valid or invalid regardless of reference and even truth. This is why formal logic, the theory of inference, does not contain the semantic concept of reference.)

The second mistake of Howson and Urbach's is the Bayesian dogma that 'purely personal beliefs' have a scientific standing. If they had, religious beliefs would play a role in the finished products of scientific research. The third mistake is the statement that all scientific inferences are inductive, when in fact induction plays an insignificant role in advanced science before one reaches the stage of contrasting theoretical predictions against empirical data (Popper, 1959b; Bunge, 1960). No wonder that Howson and Urbach do not examine any of the scientific theories about chance events, such as quantum mechanics and genetics.

Likewise, Berry and Stangl (1996: p. 8) write about Bayesianism in biostatistics: 'although it is comforting when two [statistical] analysts give the same answer, subjectivity leading to diversity is quite appropriate. Differences of opinion are the norm in health science and in science generally, so an approach that explicitly recognizes differences openly and honestly is realistic, forthright, and welcome'.

An obvious rejoinder to that extraordinary statement is this. First, biomedical models are expected to tell us something about diseases, not about the opinions that experts hold about them. Second, science and technology, including medicine, are not mere matters of subjective assessment or opinion. True, the sick Sumerians would exhibit themselves in front of their houses and solicit the opinion of passersby. But one millennium later Hippocrates started transforming medical *doxa* (opinion) into medical *episteme* (science). Can we afford to go back four millenia?

It might be rejoined that any ideas can have bad consequences if handled incompetently. My point is that there is no way that Bayesianism (or alchemy, or parapsychology) can be handled competently, because it is radically false. Indeed, (a) probability estimates should be just as objective as length or weight estimates; and (b) probability applies legitimately only to genuine random events, such as quantum tunneling, the drips of a leaky water tap, gene mutation, the distribution of weeds in a cultivated plot, the arrival of calls at a telephone exchange, and random sampling.

To appreciate the enormity of the Bayesian attempted counter-revolution consider, for instance, the relation between the HIV virus and AIDS. It is well known that, whereas those who have this disease test HIV-positive, the converse is not true: some individuals have lived with the virus for a decade or more without developing AIDS. Suppose then that a given individual has contracted that virus, and that we wish to ascertain the probability that he also has, or will soon develop, AIDS. Presumably, a Bayesian would set $Pr(AIDS/HIV) = Pr(HIV/AIDS)\ Pr(AIDS/Pr(HIV)$. Further, since the individual in question has tested HIV-positive, our Bayesian is likely to set $Pr(HIV) = 1$. And, since it is known that whoever has AIDS also has the HIV virus, $Pr(HIV/AIDS) = 1$. Thus, Bayes' formula simplifies to $Pr(AIDS/HIV) = Pr(AIDS)$. However, this is known to be false: in fact, HIV is necessary but not sufficient to develop AIDS. So, if AIDS researchers were to adopt Bayesianism, they would not try to discover the causes that, jointly with HIV infection, lead to AIDS.

Talk of probability without chance is pseudoscientific and therefore imprudent, particularly if the alleged probabilities are subjective, in which case they are actually intuitive plausibilities or verisimilitudes. One should not gamble with life, justice, peace, or truth. And one should not confuse the objective probabilities of random events with mere intuitive likelihoods of such events or the plausibility (or verisimilitude) of the corresponding hypotheses in the light of background knowledge (Bunge, 2003). As Peirce (1935: p. 363) put it, this confusion 'is a fertile source of waste of time and energy'. A clear case of such waste is the current proliferation of rational-choice theories in the social sciences, to model processes that are far from random, from marriage to crime to business transactions to political struggles (see Bunge, 1996a, 1998a, 1999a).

CONCLUDING REMARKS

In conclusion, Bayesian statistics and inductive logic are triply wrong: because they assign probabilities to statements; because they conceive of probabilities as subjective; and because they invoke probabilities in the absence of randomness. Adding arbitrary numbers to any discourse does not advance the search for truth: it is just a disguise of ignorance. Subjective experience is a subject for scientific (psychological) investigation, not a surrogate for it. And subjectivism, whether Berkeley's, Kant's, Fichte's, Husserl's, or Bayesian, is a mark of either antiscience or pseudoscience. Learned ignorance is still ignorance. In particular, diagnosis with the help of made-up numbers is not safer than without them; and trial by numbers is no more fair than trial by water or by combat. Thou shalt not gamble with life, justice, peace, or truth.

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