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Book and Software Reviews

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S. James Press and Judith M. Tanur. The Subjectivity of Scientists and the Bayesian Approach. New York: Wiley, 2001. ISBN 0-471-39685-0. 224 pp+appendix, references, index, 79.95 USD.

One of the things that are difficult to teach to methods and statistics students is the important role of subjective beliefs in science. The leading conception of the business of scientists is that they study facts, taking great care to be objective, and then cautiously come to their conclusions about these facts. The public idea of scientific research is still firmly grounded in 19th-century inductivism, a philosophic perspective that is nicely summed up by a quotation from Sherlock Holmes: "It is a capital mistake to theorize before one has data" (from Scandal in Bohemia, first published in 1892). It is precisely this view of science that Press and Tanur set out to eradicate. In their own words: "We will show that the most famous scientists in history have all used their hunches, beliefs, intuition, and deep understanding of the processes they study, to one extent or another, to arrive at their conclusions" (p. 1, Introduction).

The authors set the scene in the first chapter. Here, they explain that they have two goals in their book. First, they want to show that the notion of scientific objectivity is only partially true; science has both objective and subjective elements. Second, they want to show that modern Bayesian statistics is a valuable way to incorporate subjectivity in scientific research. Using various examples, they go on to discuss what they mean by subjectivity and objectivity, the evident diversity in scientific methodology, and the role of creativity and thought experiments in science. In addition, they discuss the practice of blinding the scientists against knowing which of the subjects are in the experimental group and which are in the control group. This practice is common in biomedical research, but is now also used in some physical experiments. This is an indirect admission of the existent risk of subjectivity even in a strict science such as particle physics.

Press and Tanur demonstrate the role of subjectivity in the scientific process by reviewing the work of a set of prominent scientists. In Chapter Two, they describe how they made their selection of prominent scientists. First, they selected five scientists because there were strong subjective elements in their work: Johannes Kepler, Gregor Mendel, Robert Millikan, Cyril Burt, and Margaret Mead. These are all discussed in Chapter Three. In addition, they take all the scientists from a well-known book (Meadows 1987) with scientific biographies of twelve scientists: Aristotle, Galileo, William Harvey, Isaac Newton, Antoine Lavoisier, Alexander von Humboldt, Michael Faraday, Charles Darwin, Louis Pasteur, Sigmund Freud, Marie Curie, and Albert Einstein. The lives and accomplishments of these twelve scientists, selected by someone else than the authors, are discussed in considerable detail in Chapter Four. Chapter Five, the last chapter, introduces Bayesian statistics, and argues that this is a fruitful approach to incorporate subjectivity in scientific research. Press and Tanur give several examples from different scientific fields to explain their position.

The stories Press and Tanur tell about their chosen scientists are interesting, and demonstrate clearly the strong role of subjective beliefs and hunches in science. This applies most to the five scientists chosen for their extreme subjectivity: Kepler, Mendel, Millikan, Burt, and Mead. Kepler had strong beliefs which inspired his cosmology that he massaged his data to fit his theory. Mendel and Millikan also massaged their data, and Burt has even been accused of fabricating his data. Mead appears to have let her subjective judgment steer the data collection to such an extent that one critic called her work so unscientific as to be ''not even wrong'' (p. 47). Yet some of these scientists, who were so convinced of their beliefs that their scientific practices bordered on scientific fraud, did discover important scientific laws. Kepler established the three laws of planetary motion, which are still known as ''Kepler's laws.'' Mendel's laws of heredity still stand, and Millikan's value of the electric charge of the electron was accurate enough, despite his practice of discarding observations that did not fit his theory. Apparently, strong subjectivity can go together with making major scientific discoveries. On the other hand Mead's interpretation of Samoan culture has been strongly criticized, and whether Burt's ideas about the hereditary basis of intelligence are correct is still unsettled. But the extent to which Burt and Mead let their subjectivity dominate their scientific practices has damaged their scientific reputation beyond repair. So, subjectivity in science is not always good.

The twelve other scientists discussed in Chapter Four are less extreme, but still show considerable subjectivity in their work. Together with the stories about the five extremely subjective scientists, these other stories present a strong case for the important role of subjective beliefs in science. In my view, Press and Tanur should have made a stronger distinction between the logic of scientific discovery and the logic of scientific proof. Some scientists were bright or lucky enough for their subjective beliefs to be right. So even if they massaged or misinterpreted their data to fit their beliefs, in the end they were absolved, because other scientists using rigorous methods proved they were right. In the logic of discovery, anything goes, including strong subjectivity. In the logic of scientific proof, there is considerably less freedom. The plea to recognize the important role for subjectivity in science is most relevant for making discoveries, not for proving hypotheses.

The chapter on Bayesian statistics is brief (25 pages) but manages to give a good description of the basic ideas and workings of Bayesian statistics. Press and Tanur demonstrate Bayes rule using the example of a medical diagnosis problem, where the diagnosis (posterior probability) is strongly influenced by the incidence of the disease (prior probability). They go on to discuss more complex examples, and argue that Bayesian statistics are a useful way to combine subjective beliefs (the prior probability) and empirical data into a more appropriate belief (the posterior probability).

Although I am convinced of the value of Bayesian statistics in scientific research, I am skeptical about their value in assimilating subjective beliefs of the kind described in this book. In Bayesian statistics, we are uncertain about the population value of a specific parameter (or set of parameters) in a statistical model. Bayesian statistics can then be used to combine our prior beliefs about this unknown value with empirical data, which then produces plausible values for this parameter. Press and Tanur argue (p. 217) that one could assign prior probabilities to the hypotheses that the theory is "true" or "false" and use the binomial distribution. For example, assume an experiment that can have two outcomes: a success or a failure. The probability of observing a success is 0.5 if the theory is true and 0.1 if the theory is false. Of course, if we have observed a success or a failure, we can now use Bayesian statistics to modify the prior probability that our theory is true. However, subjective beliefs like Kepler's belief that planets move in a certain way, or Einstein's belief that "God does not throw dice" (his main argument against the uncertainty principle) seem to fall into a different category. For instance, if Kepler's theory is true, the probability that planets move in ellipses is 1. If it is false, we have no idea what this probability is. The correct theory might also predict ellipses, or it might predict anything else. Philosophers of science like Kuhn and Lakatos have argued convincingly that the growth of scientific knowledge is a complex process. Kuhn has pointed out that competing theories may be incommensurable, which means that they are so different that they cannot be directly compared. Of course we can always choose to ignore such complications, somehow assign probability values to our theories and to experimental outcomes, and apply Bayesian statistics. But, somehow I doubt that any amount of Bayesian statistics would have settled the dispute between Albert Einstein and Niels Bohr as to whether the world is deterministic or probabilistic.

Still, it is fun to read all the stories about the selected scientists, and the importance of their subjective beliefs for their work is undeniable. It is good to realize that scientists are not cold-blooded logical machines, but human beings with all their follies and inconsistencies. In addition, the chapter on Bayesian statistics is a good and readable introduction. I just do not agree that Bayesian statistics solve the problem of subjectivity.

References

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