1967

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Is There a Well Defined Scientific Method?
A Psychologist's Answer

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ABSTRACT — The question "Is there a well defined scientific method?" can be answered in three ways: by referring to existing discourse on the nature of method; by pointing to concrete examples in which the method is applied in real life situations; and by creating a taxonomy of the behavioral and psychological operations that constitute the scientific process. The last way was proposed as the most fruitful of the three. Two major classes of operations and their subclasses were discussed, along with operations of thought and behavior that are antithetical to scientific method. The importance of the psychologist's contribution to answering philosophical questions that are ultimately based on human behavior and cognition was stressed.

There are at least three approaches to the problem of determining whether there is a "well defined scientific method." The first approach involves an analysis of the concepts, terms, and rules that constitute all of what we know about the scientific method. The second approach is more or less that of the empiricist who shuns conceptual analysis and resorts, instead, to pointing to actual scientists and concrete instances in which the majority agrees that the scientific method is being applied. The third approach is both a blend of the first two and, I believe, an innovation, since it requires the application of the tools of modern psychology to a problem that, as far as I am aware, has not been so attacked.

When I learned about the topic of the symposium, my first reaction was to adopt the first approach. I turned to dictionaries, the Britannica, the works of some philosophers of science, and even to a few introductory biology and physics texts in which the first chapters nearly always have a few general statements on the nature of the scientific method. Despite differences in emphasis, there was a substantial amount of agreement among these sources. In brief, "scientific" is an adjective referring to behaviors, verbal statements, or other symbolic representation that are in accord with the rules, principles, or methods of science. Science itself is generally considered to be a body of knowledge containing, as its most simple unit, theoretical or empirical propositions, whose aim is to elicit universal assent on matters concerning the empirical order of things. Such assent is usually accorded (and often only provisionally) such propositions after careful examination of the procedures employed by the scientist to arrive at the propositions. For example, if a scientist claims that variables A and B are related, his audience has the right to examine the proposition in terms of what he actually did (the method he actually used) to get to the position where he could actually make such a claim. It is thus quite apparent that method itself is an important part of what we mean by scientific.

The word "method" derives from the Greek methodos having to do with a way or path to some destination. But a way of going toward something is not all that is meant by the word as we use it today. What is further implied is that the way is an orderly, systematic, and conventionally established mode of doing something. Synonyms for it are "procedure," "rule," "systematic fashion," and "manner." That is, the word "method" implies a planned, predetermined, and systematic way of accomplishing an end or arriving at a goal. Second-level implications of the term are (1) that we are conscious of all aspects of the method used (we are conscious of it because we are directly responsible for constructing it—or vice versa—hence, it is determinate and predictable), and (2) that we can transmit the method to others once having learned it ourselves.

So far the written sources have done us well. We could read further and discover that scientific method entails observing, producing hypotheses, conducting experiments to test the hypotheses, drawing conclusions, making inductive and deductive inferences, etc. The list could easily be extended, and we could learn much of what goes into employing the method by means of the first approach. If all this is so, why not be satisfied with the way things are? Why not consider the question posed to this panel as already answered in the books? As a psychologist, I don't know exactly why we should not be satisfied. The person who asked it was, in our terminology, motivated by epistemic curiosity, and the longer I think about the question, the more my epistemic curiosity is also aroused and the less satisfied I become with answers from written sources.

With dissatisfaction with the first approach implanted in at least two of us, let us go now to the second. The second approach, at first glance, is in some ways revolutionary and at the same time defeatist. The proponents of it say, in effect, "Why quibble with words about method and how well—or ill—defined it is? Break out of the language game and look at reality. Look at scientists themselves and what they do. It's all very simple. The way they do what they do is their method." What these proponents are suggesting is that we ignore written discussion and theories about method and build up an answer to the question by looking at scientist after scien-
tist, instance after instance, in which the scientific method is employed. We should do this in the same way that we gradually build up a composite image of a Republican or Democrat by attending convention after convention. The obvious hope underlying all this is that after exposure to n + 1 number of instances in which the scientific method is observed in action, we should soon develop a concept of method and, ultimately, some idea of how well defined the method is. This approach has one advantage: It forces us to look at method as it actually exists in practice. However, as we apply this approach to the problem in the crude fashion suggested, difficulties become immediately apparent. Scientists obviously do a multitude of different things in their pursuit of knowledge. The physicist can control variables systematically with relatively great precision; the astronomer can only passively observe much of what interests him, but can still be relatively precise; and the psychologist can both observe and manipulate many of his variables, but with relatively little or no precision. In all three instances the objects of study differ as widely as possible, and the differences among them require equally different methodological and psychological postures toward them. Thus, any attempt to get a comprehensive picture of the scientist would have to include a very large number of different scientists. And even if we got enough scientists to form a composite picture—an interesting picture indeed—it would be such a conglomerate that it would be virtually meaningless. The empiricist (our strawman, I should say) has not brought us very far toward an answer.

What we need is a hero who, on one hand, understands the empiricist's enthusiasm for "reality" and, on the other hand, respects all the thinking on scientific method that has gone into the written discourses on it. This hero, as I indicated earlier, is the psychologist. He could be virtually anyone but, whoever he is, he must have the psychologist's skills and the psychologist's attitude toward the problem.

The psychologist's claim to the role of hero rests on the following argument: According to him, the question, "Is there a well defined scientific argument?" has as its referent or object a particular type of human behavior, not method and not people. This human behavior is focused on obtaining information that must meet certain scientific requirements. In a sense, scientific behavior and what we mean by method are equivalent. Scientific behavior, like method, is a "way" from a known starting point of old information to a terminal point of information that is regarded as both new and valid. The method and behavior under ideal conditions are isomorphic. This isomorphism can be seen in the correspondence between rules as manifested in the form of symbols on paper, and the actual behavior that follows the rules; or, the other way around, between the behavior that was responsible for the original formulation of the rules and the rules themselves as they exist on paper.

Once the psychologist establishes that behavior is the main object of his study, his next step is to find (or invent) an appropriate unit of behavior that will constitute all aspects of the scientific process. A unit that is used frequently among psychologists who are interested in cognitive processes is the operation. Operations are observable acts, or acts that can be made observable, that obtain, process, and disclose information. Scientific operations are acts that constitute the complex process of obtaining information from the physical world, evaluating it, and producing out of it generally acceptable propositions. The scientist engaged in these operations appeals for universal assent for the propositions generated by them. From the moment the scientist starts acting qua scientist in response to a problematic situation, until the moment he produces propositions that account for the situation, he engages in a myriad of activities, some of which are distinct, for the most part, from other human activities, and some of which are very similar. These activities or operations constitute his method. Since they are performed by a human, they belong to the class of human behavior and hence are subjected to the same analysis to which all human behavior is subjected by the psychologist.

This approach, then, is taking the question, in a sense, out of the realm of language and concepts and into the realm of actuality, of events occurring in an observable world. In this respect, it is similar to the second approach of the empiricist, but it differs from his approach because it draws heavily upon the first approach, as we shall soon see, and it applies a more sophisticated and more precise analysis to the problem, rather than limiting itself merely to pointing to or collecting various instances.

With this in mind, let us see how a psychologist can answer the question posed to this panel. Assume that the scientific method consists of various operations and that they can be described and subjected to analysis. Our first step, then, is to attempt a gross taxonomy of operations. A taxonomy or system of classification will allow us to achieve some clarity about the scientific method in general and, possibly, to establish some boundaries to definitions. Most people will agree that the first step in organizing knowledge is to note similarities and differences in things and events. The development of classificatory schemes for things and events permits us to formulate criteria for inclusion and exclusion that ultimately allow generalities to be made about a wide variety of phenomena. The generalities in themselves are a major goal of science. However, the formation of classes also allows the scientist to make greater and greater refinements among phenomena. In other words, the boundaries between things become increasingly precise and well defined. As far as the question put to this panel is concerned, the solution lies in this approach: Are there well defined boundaries between the operations themselves that make up the scientific method and are there boundaries between these operations and others that lie outside the pale of the scientific method?

As I see it, there are two major taxonomic classifications of operations—those that are explicit, objective, and well known enough to be transmitted to others, and easily subjected to formal codification if necessary; and those that are equally as important to the scientific proc-
operations are such acts as reasoning deductively or inductively, and making sound generalizations or inferences. These operations go beyond the data, but they are still under the control of the rules of logic and mathematics and are transmittable to others.

The first class can be broken down into two subclasses: Those operations that "operate" on objects—on plants, water, insects, stars, human behavior—and those that operate on data, that is, on symbolic representations of these objects or of their properties.

In the first subclass, we include all the operations that are involved in the process of observation. This includes getting into perceptual contact with the object either directly through human sense organs or through some form of instrumental mediation, such as a microscope, strain gauge, telescope, etc. The observations may be controlled, systematic, unregulated, or opportunistic. Whatever they are, the main feature of observation is to insure that relevant information concerning the object is "channeled" into the observer. The operations that go into performing relevant and accurate observation can be subjected to control and codification and transmitted, through training, to others, etc. In brief, observation can be made into a sound and reliable method.

In addition to observation there is another member of the first subclass and it is put under the rubric of experimentation. In essence, this subclass of operations involves any activity that exerts control over objects or manipulates them in any way to change a property or properties of the objects for purposes of testing, verifying, demonstrating, or validating hypotheses or theories. Exposing guinea pigs to certain microorganisms, producing artificial erosion, freezing brains, rolling a sphere down an inclined plane, training children to remember nonsense syllables—all these represent operations upon objects, operations that can be subjected to control and systematization.

The subclass of operations that "operate" upon data include the process of re-coding raw data into appropriate symbols for analysis. This process starts with measurement itself, whereby objects are rendered into symbolic forms, such as inches, pounds, discrete responses, and positions on a hardness scale. It ends with the manipulation of the symbolic forms; the symbols are added, multiplied, classified, put into frequency distributions, converted to mean values, etc. As with the first subclass, such operations are easy to transmit to others and are under strict control of the canons or rules of logic and mathematics.

There is another member of this subclass; it consists of operations that "operate" on derivations from, or higher-order statements about, data. Included in these operations are such acts as reasoning deductively or inductively, and making sound generalizations or inferences. These operations go beyond the data, but they are still under the control of the rules of logic and mathematics and are transmittable to others.

With these two subclasses we exhaust the first major class of operations.

The second major class is set off from the first by a few distinguishing characteristics. First, as I said earlier, the characteristics are difficult to specify, often hard to transmit to others or even to be clear about oneself, and almost impossible to subject to rules. Furthermore, they are primarily cognitive in nature, that is, they are generally referred to as thought processes. There are many of them, but I will list only a few: (1) generating or constructing hypotheses concerning relations between variables; (2) formulating, or delimiting, a problem; (3) asking fruitful questions; (4) speculating about alternative outcomes; (5) discovering similarities between apparently disparate observations, discovering differences, or constructing analogies; (6) selecting criteria for bases of comparisons; (7) evaluating findings; (8) deciding between theoretical explanations; (9) producing explanations for findings. I am sure the list can be lengthened as well as modified in places. The psychologist is still far from being certain about the exact nature of many of these operations and he is not too sure whether they are independent or even scientifically demonstrable. It will be some time before we understand them sufficiently. The construction of computers and the knowledge of their operations will undoubtedly aid us in this understanding.

Well, I have briefly covered the two major classifications, like the animal and the plant kingdoms. But what about non-animals and non-plants? If scientific method can be well defined, it will be so, in part, as a result of our ability to point to behavioral and cognitive activities that are not what we think of when we think of scientific method. In other words, what human behaviors are there that do not fit our definition?

At least two classes of such activities are worth considering: The first consists of certain aspects of common sense. According to philosophers of science, when common sense is characterized by one or all of the following, we refrain from considering it a useful adjunct to the scientific method: When it fails to concern itself with measurement and accuracy; when it fails to seek to correct itself; when it puts too much emphasis on the concrete and fails to strive for the abstract and the universal; when it is unconcerned with pushing inquiry to its limit; when it fails to be systematic; and, finally, when it fails to employ an empirical test as the last recourse to settle an issue. Undoubtedly other shortcomings of common sense keep it out of the realm of scientific method.

The second class of activities is uncommon sense, that is, irrational activities and illogical thoughts, such as those that involve contradictions, absurdities, fantasies, magical thinking, nonsequiturs, etc. This class of cognitive activity disturbs scientists most of all. It is only valuable when it coincides with or illuminates reality, as has apparently been the case in true discoveries or creations that had their genuses in flights of thought that, on the surface, had no connection with reality whatsoever.

I don't know whether I have satisfactorily answered the question put to the panel. In fact, instead of cutting...
down on the work of inquiry that must be done, as all answers should do, I have created more work. Nevertheless, I have tried to present a way by which we can answer the question. Scientific method is a polymorphous concept if there ever was one. Although it has numerous referents, a systematic attempt to create a taxonomy aimed at increasing the number of classes so that the referents become increasingly more distinct from one another will, I think, reformulate the question so that it can be answered.

For me at this stage of the taxonomy, only a minute part of the question has been answered. Some aspects of the scientific method appear to be well defined, that is, they cannot be confused with neighboring aspects. Other aspects are not clear at all, and this is because psychologists have not yet developed a satisfactory taxonomy of the behavior and cognitive operations themselves. However, psychologists eventually will. And, I should add, the child psychologist who is particularly interested in the development of cognitive processes will eventually make an important contribution to the development of this ideal taxonomy. This may sound odd, but there is good historical reason to believe it. The genetic method (often referred to as the evolutionary, comparative, or historical method) has often been successful in clarifying an area and helping with the formation of a taxonomy. This method was used in comparative philology in the eighteenth century and later in biology. Today in psychology it is being employed by Jean Piaget and others to discover the nature of adult cognitive processes through a careful and painstaking analysis of earlier forms of such processes that characterize the child’s (and even the infant’s) thinking and cognitively guided actions. For example, Inhelder and Piaget (1958) and Piaget (1960) have demonstrated, although admittedly not to everyone’s satisfaction, that much of scientific thinking is reducible to formal operations, such as those found in logic and mathematics. He has shown that much of the latter is developmentally reducible to concrete operations, which appear in the late elementary school child, and which in turn, have developed out of intuitions that occur in the preschool period. And believe it or not, the intuitions, Piaget feels, are derived from sensorimotor behaviors that characterize the infant when he is faced with life’s little problems (Inhelder and Piaget, 1964).

I spend time telling you about Piaget because a multitude of things scientists do as part of their methods may not appear to be related superficially to each other. However, they may have descended from a common ontogenetic ancestor, as Piaget has been able to show in quite a few instances (for example, adult classificatory behavior is clearly developmentally related to the groups of objects spontaneously formed by the young child). At any rate, as a child psychologist specializing in this area, I can only assure you that a taxonomy of scientific operations partly based on the genetic method has a good chance of surviving.

And here is the moral of my story and my challenge to philosophy: There are many philosophical issues that need no extensive up-to-date knowledge of the empirical order. But there are also many issues that inevitably mesh with empirical problems in the most unavoidable way. These are the issues and problems that are faced mostly, I assume, by philosophers of science. Many of these problems are ultimately related to human behavior or human cognition (there is no question that epistemology is inextricably tied up with psychological phenomenon). Since this is the case, I see no reason why the psychological expert should not be called in to help out, especially when the philosophical question is aimed at obtaining a precise and unequivocal answer about the way things are in nature.

References

