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PHILOSOPHY OF SCIENCE, WITH SPECIAL CONSIDERATION GIVEN TO BEHAVIORISM AS THE PHILOSOPHY OF THE SCIENCE OF BEHAVIOR

J. Moore

University of Wisconsin-Milwaukee

The philosophy of science is the branch of philosophy that critically examines the foundations, assumptions, methods, products, and implications of the activity called science. The present sketch reviews the historical development of the philosophy of science, representative individuals in the field, and topics of long-standing interest. The sketch is intended to prepare readers for subsequent discussions on behaviorism, cognitive psychology, and the meaning of mental terms.

Key words: philosophy of science, logical positivism, operational definition, intervening variable, hypothetical construct, mediational neobehaviorism, radical behaviorism

The philosophy of science is the branch of philosophy that critically examines the foundations, methods, products, and implications of the activity called science. Representative topics in the philosophy of science include (a) the origin and nature of scientific language (e.g., terms, concepts, statements, laws, theories, explanations, predictions), (b) the validity of scientific language (e.g., definitions, meanings, applications), (c) the nature of the scientific method, (d) the nature of scientific reasoning, and (e) models of scientific activity. This sketch reviews the historical development of the philosophy of science, representative individuals in the field, and topics of long-standing interest. The aim is to prepare readers for subsequent discussions of behaviorism, cognitive psychology, and the meaning of mental terms.

Precursors

Auguste Comte (1798–1857) is credited with founding a philosophical position underlying much scientific reasoning: positivism. Positivism assumes that scientific knowledge is the highest form of knowledge, and that scientific knowledge comes from studying directly observable and measurable events. Other knowledge claims, for example, those based on religious or metaphysical assumptions, are held to be imperfect because they are not derived from actual publicly observable experiences. According to positivism, then, the world consists of laws and principles that are discovered through direct observation. If we do not know enough about some aspect of nature,

I thank Marshall Dermer for helpful comments on an earlier version of this article. Correspondence concerning this article should be addressed to J. Moore, PhD, Dept. of Psychology, University of Wisconsin–Milwaukee, Milwaukee, WI 53201 (e-mail: jcm@uwm.edu).

we must study, measure, and otherwise directly observe our subject matter more closely. Indeed, if we cannot do so, we must assume that the purported subject matter does not even exist. Moreover, scientific knowledge has the degree of certainty necessary to be regarded as foundational, for example, as a basis for structuring society and thereby improving it.

Despite the popularity of positivism and empiricism, debates about the nature of scientific knowledge were prominent in late-19th-century Europe. For example, Ernst Mach (1838–1916) was a positivist in the sense that he emphasized that scientists should be strictly empirical: They should emphasize what they directly experienced as they worked—in Mach's words, their "sensations." According to Mach, scientific statements should be regarded as economical, abstract summaries or expressions of the facts of a scientist's interactions with a subject matter, rather than as metaphysical statements about a supposed underlying reality. In the area of psychology, Mach embraced the psychophysics of Fechner and the overall system of Wundt, because those positions emphasized the direct experience of the individual. However, Mach was skeptical about the existence of atoms, principally because they had not been directly experienced.

Henri Poincaré (1854–1912), a mathematically oriented French theoretical physicist, took a slightly different approach. One of his concerns was "simultaneity": How was it possible to determine whether a clock striking noon in Paris was simultaneous with a clock striking noon anywhere else in France? An observer could not stand in one place and see both clocks at the same time. Poincaré's solution was to rely on mathematics. The speed of electricity was known, and the distance between the two clocks was known. If an electrical signal could be sent from the first clock to the second clock, and the time on the second clock adjusted to compensate for the distance the electrical signal had traveled, the computation would yield the required simultaneity. For Poincaré, therefore, higher order scientific concepts did not refer to things that could be directly experienced. Rather, higher order scientific concepts followed from the outcome of conventionally accepted procedures, like mathematics. The importance of any concept was determined by how well it promoted effective action.

Developments in physics in the early 20th century represented a particularly thorny matter. In 1905, now sometimes called "The Wonderful Year," a relatively unknown patent analyst in Berne, Switzerland, named Albert Einstein (1879–1955) published four extraordinary scientific papers. These papers set forth his revolutionary ideas on such topics as a space–time continuum, the interchangeability of matter and energy, atomic theory, and the theory of relativity. These papers argued for quite a different conception of scientific knowledge than had previously been considered, one that depended on the viewpoint of the observer. Einstein's name and contributions to theoretical physics are now well known.

Such contributions as Einstein's posed significant challenges to the scientific thinking of the day. How were the traditional contributions of positivism, observation, and even empiricism itself to be upheld, given the decidedly nonobservational, inferential, and computational advancements in the areas of the very small (atomic theory, quantum mechanics) and the very large (relativity theory)? Indeed, if scientific knowledge ultimately depended on the viewpoint of the observer, as Einstein's work suggested, how was a corpus of generalizable scientific knowledge even possible?

Logical Positivism

In the decades after World War I, various groups of scholars fiercely debated how to maintain a commitment to empiricism and objectivity, given the contemporary advancements in science noted above. The work of two groups proved particularly important: the Berlin Society for Empirical Philosophy, which formed in Berlin, Germany; and the Vienna Circle of Logical Positivists, which formed in Vienna, Austria. Both groups adopted a general orientation that entailed (a) anchoring basic concepts in observation and measurement, and then (b) extending these basic concepts with the techniques of formal symbolic logic.

The members of these groups came from philosophy, mathematics, the natural sciences, and the social sciences. Accordingly, they drew their inspiration from their own disciplines and many other sources. As suggested above, one source was formal symbolic logic, such as found in the work of the philosopher Gottlob Frege (1848–1925). Another was Bertrand Russell (1872–1970), who together with Alfred North Whitehead (1861–1947) had applied formal logic to the philosophy of mathematics and produced a monumental three-volume work titled Principia Mathematica (Whitehead & Russell, 1910, 1912, 1913). A third source was the aforementioned Ernst Mach, who had emphasized the interactional yet nevertheless empirical nature of science (although, ironically, he did not embrace formal logic). Indeed, an early name for the Vienna Circle, before they adopted the name of Logical Positivists, was the Ernst Mach Society. A fourth influence was Ludwig Wittgenstein (1889–1951). Wittgenstein had published an extraordinary book titled Tractatus Logico-Philosophicus (Wittgenstein, 1922), in which he ambitiously sought to apply logical reasoning to answer questions about the fundamental nature of our language—in much the same way that Russell had applied logical reasoning to answer questions about the fundamental nature of mathematics. For Wittgenstein, a language ideally provided a logically consistent picture of the world. It reflected the world as it was but did not provide an ultimate, metaphysical meaning for that language. Indeed, he rejected the very idea that that sort of meaning was a suitable concern for philosophy. He self-confidently concluded that nothing further was required in philosophy.

The *Tractatus* struck a resonant chord with the logical positivists and others with similar orientation, who studied the *Tractatus* in great detail. As had Wittgenstein, the logical positivists came to see philosophy as essentially a means for clarifying language, rather than making metaphysical pronouncements about nature. Indeed, metaphysical statements were to be avoided at all costs. Many would take the beginning of the second quarter of the 20th century as the starting point of a philosophy of science.

The Principles of Logical Positivism

What, then, were the basic principles of the logical positivists? The listing below is representative; however, readers should understand that logical positivism was an evolving position during the second quarter of the 20th century. Not every logical positivist would have expressed his views in the ways below, not every principle was expressed during the same time period, and any particular logical positivist might well have chosen to express his views on one or more of these topics differently at different times.

1. Philosophy was about language, not metaphysical pronouncements concerning the world. In fact, metaphysical statements were to be rejected.

2. To be meaningful, statements had to be subject to verification, or, to use a later term, *confirmation*. They had to be capable of being checked against the facts of experience. The language could superficially be of any form. Indeed, the logical positivists developed a principle of tolerance, according to which statements were not automatically rejected if they were not of a particular form or did not use a particular vocabulary. Rather, the logical positivists simply called for some way to determine the meaning of a statement through empirical testing. Metaphysical statements could not be so tested and hence were not considered meaningful.

3. The purpose of the analysis of language was to provide a rational reconstruction of knowledge claims. Of particular interest was imparting a logical structure and coherence to those claims in a way that did justice to the accomplishments of science.

4. What was important was establishing the context of empirical or logical justification of those knowledge claims (i.e., the context of justification), rather than establishing the context of how the claims came to be made (i.e., the context of discovery). The context of discovery was a matter for psychology or sociology or history, but not a philosophy of science. Moreover, science was transpersonal and did not depend on the particular characteristics of scientists or their backgrounds.

5. A clarification of scientific language would reveal its cognitive significance. The techniques of science afforded the one fundamental source of genuine knowledge, which is to say knowledge that was cognitively significant. Language might also have emotional significance, but this sort of language was not involved in science and did not have the requisite meaning. It could not be analyzed by being checked against the facts of experience. An example was a value judgment, which was held to be something entirely different—not analyzable by any of the prescribed means and hence not of scientific concern.

6. Statements could be either analytic or synthetic in character. Analytic statements were tautologically true. An example is “A bachelor is an unmarried man.” Synthetic statements were only contingently or empirically true. An example is “Jones is a bachelor.” We have to determine whether Jones is married before we know whether the statement is true.

7. The scientific vocabulary consists of three sorts of terms: logical, observational, and theoretical. *Logical terms* are terms from symbolic logic: *and, or, implies, subset of*, and so on. *Observational terms* refers to terms that come about as a consequence of direct observation and measurement with our senses or instruments. *Theoretical terms* are unobservable and come about as logical constructions or inferences.

8. Theoretical terms can be either exhaustively or partially defined. In

an exhaustive definition, the meaning of a term is entirely reducible, without remainder, to observables. The term has no meaning beyond its immediate use or application. More specifically, an exhaustively defined term does not necessarily refer to anything that actually exists in the world at large. Early logical positivism embraced exhaustive definitions. In a partial definition, the meaning of a term is linked to observables through logical operations, but the term can also have further meaning, beyond the immediate use or application. Given that the term has a further meaning, it follows that the term must refer to a "something" that "exists" in some sense, in a way that an exhaustively defined term does not. Later logical positivism embraced partial definitions. In recognition of this change, later logical positivism is sometimes referred to by a different name, *logical empiricism*.

9. All sciences can be unified in both content and method. The content is reducible to physics and a description in a "physical-thing language." The method, and what is ultimately called an explanation, are reducible to the hypothetico-deductive method. According to this method, the scientist makes a statement, identifies initial conditions, and deduces a potential observation (i.e., a prediction) from the statement. The scientist then carries out research to determine if the deduction obtains. If it does, the event is considered to have been explained. This form of methodology and explanation may be called the *covering law* method. The statement is a covering law in the sense that it covers the event to be explained. Technically, the covering law could not be proved as true, as that would commit the fallacy of affirming the consequent. At most, it could be supported or corroborated.

10. As described above, scientific statements needed to contribute to an explanation of the event in question. To do so, scientific statements needed to be testable against the facts of experience: Could measurements be taken that would confirm the statements? The important question was how to get to that point. Two quite different orientations to this question developed in logical positivism. One was called an instrumentalist orientation, and the other a realist orientation. According to an instrumentalist orientation, derived to some extent from Poincaré, it is enough to assume that it is "as if" some term or concept refers to a thing that actually exists in nature, with the properties ascribed to it, and then proceed. One need not assume that the terms, concepts, and laws identify things that exist in nature in just the ways spoken about. The terms, concepts, and laws of science are simply conventional ways of speaking, with no more implication than measuring length in terms of inches or centimeters. In contrast, according to a realist orientation, the goal of science was to develop and refine statements until they did correspond to things that were assumed to literally exist in nature. The more precise the statements were, such as by being quantitative, the better they were. Interestingly, however, no consensus emerged among the logical positivists as to which orientation was preferable. Instrumentalists charged that realism ignored the empirical, experiential nature of science. Realists charged that instrumentalism made the opposite error and allowed too much subjectivity.

Further Developments

The rise of Nazism in the 1930s forced many of the logical positivists to leave central Europe and relocate elsewhere. Particularly hospitable homes were found in Scandinavia, England, and the United States. There, the logical positivists continued to develop their ideas, and, when necessary, to modify them. For example, one important problem concerned whether theoretical terms and concepts were exhaustively or only partially reducible to observations (see above). The early position, springing from analyses developed in the 1920s, was that theoretical terms must be exhaustively reducible to observations. However, a problem arose with exhaustive definitions. Suppose a pane of glass broke when a stone was thrown against it. Suppose further that a researcher explained the breaking of the glass by referring to its "brittleness." Brittleness was not a directly observable property like length or weight. Rather, it was an inferred, theoretical term or concept that could be tested empirically by throwing a rock against the pane of glass. However, where was brittleness in the absence of the test condition? Did the same pane of glass have comparable brittleness on a different day? Did other panes of glass have comparable brittleness? In light of such questions, the logical positivists made a significant move and embraced partial definitions in the mid 1930s (Carnap, 1936, 1937). Brittleness was accepted as a dispositional property of the glass, existing even when a rock was not thrown against it. It also existed in other panes of glass. As noted earlier, many think that the move was so significant that the movement should thereafter be identified by a new name: logical empiricism. In reflection of this development, we will use the term *logical empiricism* in the remainder of this article.

One of the logical empiricists who emigrated to the United States was Herbert Feigl (1902–1988). He joined the University of Minnesota, where in the late 1930s and early 1940s he discussed issues of the day with a young faculty member in the Psychology Department there named B. F. Skinner. Skinner had been interested in the history and philosophy of science from his graduate student days, as reflected, for example, in the work of Mach and Poincaré, but he never subscribed to the formal symbolic logic of logical empiricism. Skinner left Minnesota in 1945, but Feigl was instrumental in establishing an intellectual center there, as well as a long-standing publication outlet referred to as the *Minnesota Studies in Philosophy of Science*. In its pages, noted philosophers and scientists set forth their positions on both technical and theoretical matters pertaining to the philosophy of science.

Another of the logical empiricists who found a home in the United States was Gustav Bergmann (1906–1987). Bergmann worked at the University of Iowa, where he published numerous articles on the philosophy of science as applied to psychology with a young faculty member in the Iowa Psychology Department, Kenneth W. Spence (1907–1967). However, their work was very different from Skinner's (Bergmann & Spence, 1941; Spence, 1944, 1948).

Wittgenstein established himself in England during approximately this same time, although despite his seminal influence, he was never a logical empiricist, as such. Unlike his earlier work, and somewhat like others in England and elsewhere, Wittgenstein now emphasized the study of language through an examination of the actual conditions of use, rather than via a formal analysis. In so doing, Wittgenstein virtually repudiated the position that he had taken in his earlier *Tractatus* and that had been so influential in the founding of logical positivism. According to the later Wittgenstein, language was akin to a game, played by speakers according to a shared set of rules. Although Wittgenstein had less to say explicitly about philosophy of science, he did not view scientific language as fundamentally different from any other sort of language. Indeed, particular favorite targets of Wittgenstein's critical analyses were (a) the language of psychology concerned with first-person reports and (b) the commitment of various views of that language to both Cartesian and earlier logical positivist views. His principal work, published posthumously in 1953, was *Philosophical Investigations*.

Psychology: The Rise of Behaviorism

In 1913, John B. Watson (1878–1958) launched the first phase of the "Behavioral Revolution" by proposing a form of behaviorism—here called classical S–R behaviorism—to counter the influences of structuralism, functionalism, and the extant concern about mental life. This form emphasized publicly observable stimuli (S) and responses (R), and spurned supposedly unobservable, centrally initiated processes like consciousness. However, classical S–R behaviorism proved inadequate: It could not convincingly account for the variability and apparent spontaneity of some forms of behavior. Many theorists began to point out that other sciences seemed to be making progress by postulating unobservables to deal with their difficult problems. Why should not psychology?

The result was the second phase of the Behavioral Revolution. In this second phase, unobserved, "organismic" terms were inserted between the S and R of classical behaviorism. These organismic terms were held to "mediate" the relation between S and R, thereby accounting for the variability between the two. In this mediational approach, external stimuli (S) are held to activate some intervening, internal process or organismic entity (O) that is causally connected in a complex but systematic way to an eventual response (R), and the mediating process or entity is taken as the proper focus of psychological science, rather than the response itself. In other words, the response is functionally related to the mediator inside the organism, rather than to the environment, because the organism is in direct contact with only the mediator, rather than the environment. An example might have been mood or attitude. If an organism's behavior was variable, it was because its mood or attitude varied. This newer form of behaviorism may be called mediational S–O–R neobehaviorism, to distinguish it from its behavioristic predecessors. A special concern was neobehavioral learning theory, for example, as represented in the work of Edward C. Tolman (1886–1959), Clark L. Hull (1884–1952), and the previously mentioned Kenneth W. Spence.

At issue was how to define these organismic terms in a way that secured an "objective," scientifically respectable meaning. Let us now consider the concept of operationism.

Operationism

In 1927 the Harvard physicist Percy Bridgman (1882–1961) published *The Logic of Modern Physics*. In this book he advanced the principle of operationism: A scientific concept was synonymous with the corresponding set of experimental operations by which it was measured. For mediational neobehaviorists, operationism offered a way to eliminate the ambiguities of structuralism and introspective verbal reports. Neobehaviorists need only operationally define the publicly observable measures that counted as instances of their mediating variables. By so doing, neobehaviorists could gain the necessary agreement about the meaning of their fundamental concepts and be suitably "objective," instead of "subjective." Researchers and theorists could remain silent on whether the "subjective" actually existed, and concentrate instead on what could be publicly and objectively observed. In sum, operationism seemed consistent with the generally pragmatic character of intellectual activity in the United States by laying the foundation for practical, effective action. In addition, operationism seemed consistent with what U.S. researchers and theorists knew about logical positivism, through the emphasis on public observations, although the U.S. researchers and theorists who embraced operationism largely stopped short of embracing the formal symbolic-logic features of logical positivism.

Definitions: Exhaustive or Partial?

As originally conceived, operational definitions were exhaustive. That is, operational definitions determined all that was meant by a term, without remainder. This conception was consistent with the original logical positivist interpretation.

The interesting implication of this conception is that it restricted the meaning of a theoretical term to one and only one application. Consider the term *length*. According to an exhaustive definition, length as measured by a tape measure was regarded as one concept, and length as computed by triangulation was a second, different concept, because each was determined by a different operation. Perhaps this conception proved useful at the time because it guarded against unwarranted speculation or uninformed extension of analytical concepts when rigor and clarity of thought were at a premium.

In light of the commitment to exhaustive operational definitions, researchers and theorists in psychology questioned how scientific concepts could ever be regarded as general enough to apply to a broad range of situations. In psychology, the upshot was that MacCorquodale and Meehl (1948) published an important article suggesting that concepts could be operationally interpreted in either of two ways. First, they proposed that theoretical concepts could be interpreted exhaustively with reference to observables, admitting no surplus meaning. This interpretation continued the original interpretation as found in logical positivism until the mid-1930s and the original interpretation of operationism. MacCorquodale and Meehl suggested using the term *intervening variable* for these exhaustively defined concepts. Second, the concepts could be interpreted partially with reference to observables, admitting surplus meaning, or meaning beyond the immediate operation or application. This interpretation was consistent with the modified position found in logical positivist philosophy after the mid-1930s. MacCorquodale and Meehl suggested using the term *hypothetical construct* for these partially defined concepts.

We have now come full circle. In psychology, the mediating organismic terms were operationally defined, eventually to be regarded as either intervening variables or hypothetical constructs. Researchers and theorists could concentrate on describing the observed relation between stimulus and response, as mediated by the inferred organismic variable. As noted earlier, many psychological theories were offered during this time, for example, by Tolman, by Hull, and by Spence (who, as noted earlier, was aided in many respects by Gustav Bergmann. The theories differed in certain details but often subscribed to the tenets of mediational neobehaviorism and the interpretation of operationism described above. Consistent with the hypothetical-deductive practices advanced by the logical empiricists, researchers and theorists in psychology proposed various models and constructs and then tested their implications empirically, ideally in quantitative terms. Under the influence of operationism, and to a lesser extent logical empiricism, psychology seemed to have developed a logically coherent philosophy of science, generically known as behaviorism.

Worth noting is that B. F. Skinner (1904–1990) was roughly a contemporary with the events described above. However, the form of behaviorism that he developed, called *radical behaviorism*, did not embrace the same principles as the various forms of mediational neobehaviorism. Therefore, although Skinner's radical behaviorism was intimately concerned with language, epistemology, and the methods of science, it did not approach these topics with an assumption that human actions need to be logically analyzed to be valid. For Skinner, the important concern was pragmatism. Science is a set of rules for effective action with regard to nature. What factors cause humans to develop those rules? How have the higher-order concepts arisen from the lower? How have scientific concepts brought a sense of order to a seemingly disordered set of data? Ultimately, how are scientists who heed these rules able to operate successfully in nature? All of these questions pertained to cause-and-effect relations in psychology, rather than logic. Regrettably, the logical empiricists viewed these questions as pertaining to the logic of discovery, rather than the logic of justification, and rejected them. For Skinner, the analysis of science was nothing less than the analysis of human behavior, to be carried out using the same terms and principles as any other form of behavior. Verbal behavior was to be given a behavioral, not logical, analysis. Logic was something on the dependent-variable side that would eventually be explained by psychological principles inherent in the analysis of behavior. It was not something on the independent-variable side that explained behavior. This fundamental principle was at considerable variance with logical empiricism and, therefore, set Skinner's radical behaviorism apart from logical empiricism as well as forms of mediational neobehaviorism that appealed to logical empiricist tenets, however obliquely.

Challenges

Even within the traditional philosophy of science, however, all was not well. In this section we will briefly note several of the challenges to the general philosophical view, nominally associated with logical empiricism, that is outlined above. Readers are referred to the primary sources for more extensive analyses.

In 1951, the Harvard philosopher W. V. O Quine (1908–2000) published "Two Dogmas of Empiricism." In that paper, Quine attacked two of the fundamental principles of epistemology and philosophy of science derived from logical empiricism. The first concerned the supposed distinction between analytic and synthetic statements; the second concerned the supposed reduction of scientific concepts to some base observational level. Quine found neither tenable.

The philosopher Peter Achinstein, at this writing in the Philosophy Department at Johns Hopkins University, questioned the distinction between observational and theoretical terms. He found that the distinction could not be supported (Achinstein, 1968).

Sir Karl Popper (1902–1994), an Austrian by birth, was intimately aware of the logical empiricist movement from its inception. Popper's position resembled logical empiricism in some respects, but differed in others (Popper, 1959). As had the logical empiricists, Popper strongly endorsed the rational, deductive nature of scientific method. Similarly, he opposed what he called *historicism*, or the tendency to evaluate an idea on the basis of its historical development. However, in vehement opposition to the logical positivists, Popper challenged the notion of confirmation. For Popper, scientific theories were developed as solutions to problems. However, theories were not the sort of things that could be confirmed. To do so was to commit the fallacy of affirming the consequent. Rather, theories could only be falsified. Science advanced when false theories were eliminated, leaving only ones that had not (yet) made inaccurate predictions as survivors (in a Darwinian sense). One inconsistent prediction of a theory was enough. Indeed, the property that made a theory or any other kind of statement meaningful was its ability to identify what would falsify it when it was tested against the facts of experience.

In his influential book, *The Structure of Scientific Revolutions* (Kuhn, 1962), Thomas Kuhn (1922–1996) challenged the Popperian ideal of science as essentially concerned with logically falsifying predictions of theories. Kuhn argued that science progresses through different stages. At one stage, called *normal science*, a conventionally accepted set of ideas and procedures predominates. These ideas and procedures may be called a *paradigm*. The credibility of the paradigm may be a function of the prestige of the scientist, as well as the paradigm's ability to produce known and reliable results. However, during the course of normal science, anomalies (i.e., data inconsistent with the paradigm) accumulate. When sufficient anomalies accumulate, a revolution takes place in which a new paradigm comes to the fore. Thus, science progresses by fits and starts, with many factors involved, including such social factors as the prestige and personalities of the scientists themselves. On Kuhn's view, science is not essentially concerned with falsifying deductions from theories, and does not advance in any linear, cumulative sense, as might be expected from logical empiricism. Kuhn's view recognizes the relevance of the logic of discovery, which logical empiricism dismissed.

A final challenge we note concerns the methodology prevalent in the social sciences. The noted psychologist Paul Meehl (1967) challenged the orthodox methodology of experimental designs that compared the dependent-variable scores of experimental and control groups and, observing a statistically significant difference, concluded that the independent variable was the cause. He pointed out that many researchers and theorists assumed that if participants in the control group had received the treatment, their scores would have been consistent with those of participants in the experimental group. Ironically, this reasoning cannot be supported. In logic, the argument involves something called the "counterfactual conditional," also known as the "contrary to fact conditional." The conditionality of the premise "If the control group. . ." means that one cannot validly conclude that if the participants in the control group had received the same treatment as those in the experimental group, the scores of the former would have been similar to those of the latter. The hypothetico-deductive method, which is at the heart of logical empiricist science, falls short.

Clearly, for many scholars, science does not follow the smooth, cumulative, antiseptic progression toward ever greater knowledge that is often assumed.

Summary and Conclusions

As outlined above, much of what is called the "philosophy of science" is derived from logical positivism and logical empiricism. Some derivations have been mildly sympathetic extensions of those positions, whereas others have been distinctly unsympathetic repudiations. Interestingly, one writer stated, more than 40 years ago, that in light of the numerous derivations that existed even then, "logical positivism ... is dead, or as dead as a philosophical movement ever becomes" (Passmore, 1967, p. 56).

Indeed, an examination of the record of the second half of the 20th century indicates that concerns about philosophy of science that originally defined logical positivism and logical empiricism developed into concerns about epistemology, which in turn developed into concerns about ontology and the mind–body problem, which in turn developed into the philosophy of mind movement, where they now reside. Interested readers may trace these developments by consulting the literature. For example, a representative source for epistemology, ontology, and the mind–body problem is Feigl (1967), for philosophy of mind is Flanagan (1991), and for an emerging cognitive science orientation in philosophy of science is Harré (2001). The volumes of the distinguished *Minnesota Studies in the Philosophy of Science* also authoritatively trace these developments. Readers who are familiar with these developments may well have their own favorite sources that differ from the above.

The topic of behaviorism was mentioned earlier in this sketch. We can now outline a chain of assumptions pertaining to behaviorism, operationism, logical positivism, and, ultimately, cognitive psychology that many researchers and theorists in contemporary psychology hold:

1. That any form of behaviorism is linked to operationism and logical empiricism through a common philosophical emphasis on observables at the expense of unobservable theoretical concepts.

2. That behaviorism, operationism, and logical empiricism are all fatally flawed, precisely because of their common philosophical emphasis on observables at the expense of unobservable theoretical concepts; the challenges to logical empiricism

mentioned earlier, as well as a few others, are typically cited.

3. That cognitive psychology (or cognitive science, more generally) operates from a different philosophical viewpoint; this viewpoint accommodates unobservable theoretical concepts in a way that behaviorism, operationism, and logical empiricism never can.
4. That cognitive psychology (or cognitive science, more generally) is therefore demonstrably superior philosophically to behaviorism, operationism, and logical empiricism.
5. That any competent behavioral scientist should therefore embrace cognitive psychology and view behaviorism, operationism, and logical empiricism only with the greatest skepticism.

An early example of these assumptions is the cognitive philosopher Fodor (1968), who commented critically in the following passages on what he sees as the manifest explanatory liabilities of a behavioristic orientation to psychology based on operationism and logical empiricism:

> I think many philosophers secretly harbor the view that there is something deeply (i.e., conceptually) wrong with psychology, but that a philosopher with a little training in the techniques of linguistic analysis and a free afternoon could straighten it out. . . . Psychological metatheory has remained seriously underdeveloped. With a few important exceptions, its history during the second quarter of this century has been an attempt to work out a variety of behaviorism that would satisfy the constraints imposed on psychological explanation by an acceptance and application of empiricist (and particularly operationalist) views of general scientific method. . . . Philosophers of science . . . have realized that these doctrines are by no means indispensable to characterizations of scientific explanation and confirmation and that philosophical accounts that exploit them may in fact seriously distort the realities of scientific practice. Yet it is precisely upon these views that much of the implicit and explicit metatheory of American experimental psychology appears to rest. (pp. vi, xi–xv)

Additional examples may be found in the writings of almost any mainstream cognitive psychologist (e.g., Baars, 1986; Gardner, 1985). An important question is whether the assumptions above validly portray the relation between logical empiricism and behaviorism, especially as it involves Skinner's radical behaviorism as a philosophy of science. In this regard, Smith (1986) suggested that the relation between logical positivism and behaviorism is not as simple and straightforward as is commonly assumed. An alternative examination of that relation, particularly as it involves Skinner's radical behaviorism, is a tale for a different and important telling.

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Study Questions

1. List five representative topics studied in the philosophy of science.
2. Briefly describe one way each of the following individuals influenced the development of the philosophy of science: Auguste Comte, Ernst Mach, Henri Poincaré, Albert Einstein.
3. What were the intellectual backgrounds of the members of the "Vienna Circle"?
4. Briefly describe a contribution to logical positivism made by each of the following individuals: Gottlob Frege, Bertrand Russell, Ernst Mach, Ludwig Wittgenstein.
5. Where did the logical positivists stand on the question of whether philosophy was concerned with (a) determining the meaning of language through logical analysis or (b) issuing metaphysical pronouncements about the nature of the world?
6. Briefly describe each of the following features of logical positivism: confirmation, context of justification versus context of discovery, cognitive versus emotional significance of language, analytic versus synthetic statements, observational versus theoretical terms, exhaustive versus partial definitions of theoretical terms, physical-thing language (physicalism), hypothetico-deductive method (covering law), instrumentalist versus realist orientation.
7. Briefly describe the classical form of behaviorism that prevailed during the first phase of the "Behavioral Revolution." What were two problems that developed with this form?
8. Briefly describe the newer form of behaviorism that prevailed during the second phase of the "Behavioral Revolution." How did this form address the two problems that had developed with the earlier form? What two logical positivists emigrated to the United States and contributed to the philosophical underpinnings of behaviorism during this time?
9. In one sentence, state or paraphrase what is meant by the principle of operationism.
10. Briefly describe MacCorquodale and Meehl's (1948) distinction between the intervening variable and hypothetical construct interpretation of theoretical terms in psychology.
11. List any three challenges to logical positivism noted at the end of the article.
12. State or paraphrase any three assumptions from the chain of five assumptions pertaining to behaviorism, operationism, logical positivism, and ultimately cognitive psychology that many researchers and theorists in contemporary psychology hold.