Cognitive Science

An Introduction to Mind and Brain

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4.4.2 The philosophy of science

4.4.2.1 The influence of logical positivism

If we were to place our bets on who is most likely to have empirical knowledge, we would be wise to bet on scientists. In particular, the phenomenal successes of physics, chemistry, and biology in the twentieth century have attracted the attention of philosophers trying to explain knowledge.

What is scientific knowledge? It seems to involve the formulation of hypotheses and the testing of those hypotheses by carefully controlled observations. Well-tested hypotheses are those most likely to be regarded as true theories. The continued activity of hypothesis formation and hypothesis testing thus gives rise to knowledge of the world and theories that explain how the world works. Philosophers have been interested in explaining in more detail how the processes of hypothesis testing and theoretical explanations work. Many philosophers of science have tried to explain testing and explanation in terms of logic. Foremost among such philosophical explanations of scientific activity were the logical positivists of the early twentieth century. Here we describe the two main outgrowths of logical positivism: the hypothetico-deductive model of theory development and the deductive-nomological model of scientific explanation.

4.4.2.1.1 The *hypothetico-deductive* model of theory development

Scientific knowledge is codified in the form of scientific theories. Prominent theories include the oxygen theory of combustion, and Einstein's General and Special theories of relativity. Where do theories come from? The basic answer that we inherit from the logical positivists is that theories start as hypotheses – educated guesses. Then these hypotheses are subjected to tests, and if they pass the tests, they rise to the level of theory. The hypotheses are confirmed and the process of confirmation bestows justification, and thus, we start with hypothesis and wind up with knowledge. The logical positivists offered a view of the logical structure of theory development and hypothesis testing known as the hypothetico-deductive (H-D) model of theory development. According to the H-D model, after a scientist generates a hypothesis, he then deduces implications of the hypothesis: statements logically derivable from the hypothesis. Next he performs observations and experiments to see if any of these implications of the hypothesis are true. If the implications of the hypothesis are held to be true, the scientist regards the hypothesis itself to be shown true.

Carl Hempel (1965) illustrates H-D with the example of Ignaz Semmelweis' work during the 1840s on childbed fever. Semmelweis observed cases of childbed fever contracted by women who gave birth in his hospital. He noted that cases were especially frequent among women for whom deliveries were handled by physicians instead of midwives. Semmelweis' key insight into the cause of childbed fever came when he observed that a physician came down with similar symptoms upon injuring himself with an instrument during an autopsy. Semmelweis hypothesized that "cadaveric material" on the instrument caused the disease, and that, similarly, the physicians associated with outbreaks of childbed fever had cadaveric material on their hands prior to delivering babies. Semmelweis tested this hypothesis by examining its implications. One implication of the hypothesis that cadaveric material is the cause of childbed fever is that its removal from the hands of physicians would result in a decrease in cases of childbed fever. Semmelweis tested this implication by requiring that physicians wash their hands in chlorinated lime prior to examining patients (which he assumed would remove the cadaveric matter). He observed that groups of women examined by physicians who washed with chlorinated lime had lower incidence of childbed fever than groups of women examined by physicians who did not.

The example of Semmelweis' hypothesis and test conforms to the H-D model in the following way. His hypothesis took the form of a general statement: "Any woman in the hospital who comes down with childbed fever must have been exposed to cadaveric material." An implication of the hypothesis is the statement "If some woman is not exposed to cadaveric material she will not contract childbed fever." Semmelweis tried to set up conditions in which he could observe women not exposed to cadaveric material by having a group of women examined only by physicians who had washed with chlorinated lime. Such women turned out to have lower incidences of childbed fever, thus confirming the initial hypothesis.

Another way in which hypotheses are thought to be confirmed is by way of induction. Semmelweis' observations could be formulated as a series of observation statements, statements of particular states of affairs such as "Jane Doe was exposed to cadaveric material and contracted childbed fever," "Mary Smith was exposed to cadaveric material and contracted childbed fever," and so on. His hypothesis took the form of a law-like general statement: "Any woman exposed to cadaveric material will contract childbed fever," which is a general statement inductively supported by a collection of particular observations.

4.4.2.1.2 The D-N model of explanation

One of the main goals of science is to explain things. An idea that goes back as far as Aristotle is that events are explained by showing that they conform to general laws. This idea was developed by the logical positivists into the deductive-nomological (D-N) model of explanation. The gist of the D-N model is that a phenomenon is explained by showing that a description of that phenomenon is deducible from one or more statements of law: statements that take the form of universal generalizations. One example of a law is Newton's law that force equals mass times acceleration. This law may be expressed as a universal generalization of the form, for any quantity of force exerted by an object, that force is the product of that object's mass and that object's acceleration. The explanation of why some particular object exerts the force that it does will involve showing that the relations of its force, mass, and acceleration are derivable from Newton's law. (Note the similarity to foundationalist accounts of justification discussed above.)

Combining the H-D model with the D-N model yields the picture of science depicted in Figure 4.1. According to D-N, particular phenomena are explained by showing how they are deductively derivable from general statements of law. According to H-D, general statements of law are supported by inductive arguments, the premises of which are observation statements: descriptions of observed particular phenomena.

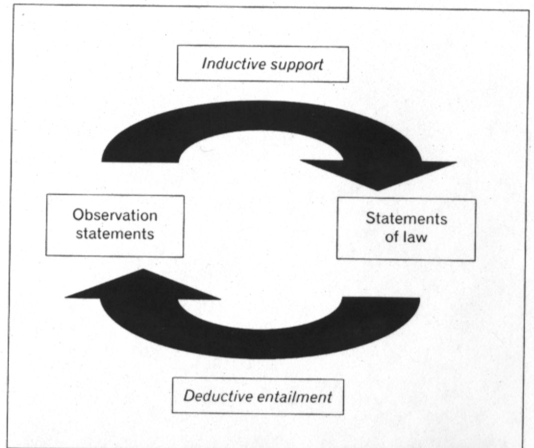

FIGURE 4.1 According to the H-D model, observation statements offer inductive support for statements of law, and according to the D-N model, phenomena are explained by showing that observation statements describing the phenomena are deductively inferred from the statements of law

POPPER'S CRITIQUE OF CONFIRMATION

Karl Popper (Popper 1958 [1935]) attacked the positivists' view that hypotheses could be confirmed. Popper argued that hypotheses could only be falsified.

According to the H-D model, the logic of the relation of hypotheses and tests had the following form:

Premise 1: Hypothesis H entails prediction P.
Premise 2: Prediction P is true.
Conclusion: Therefore hypothesis H is true.

Popper pointed out that any argument of this form embodies fallacious reasoning. The key to seeing this is to realize that statements of the form "If P then Q" are logically

continued

equivalent to "P is sufficient for Q" and "Q is necessary for P." In the above schematic argument, the second premise involves the truth of only one of the necessary conditions of the hypothesis, which is thus insufficient for the truth of the hypothesis. This fallacious form of reasoning is known as the fallacy of affirming the consequent. Here is a more obvious example of the fallacy:

Premise 1: If my car starts then the battery works.
Premise 2: My battery works.
Conclusion: My car will start.

Popper argued that instead of attempting to verify, the best that scientists could do to test for hypotheses was to try to see if they were false. Consider arguments of the following form:

Premise 1: If Hypothesis H is true, then Prediction P would be true.
Premise 2: Prediction P is false.
Conclusion: Therefore hypothesis H is false.

Here we have a valid form of reasoning known as modus tollens. This reasoning is valid because the second premise shows the failure of one of the necessary conditions on the truth of the hypothesis. Thus, Popper argued, scientists should try as hard as possible to devise tests that could falsify hypotheses. The hypothesis that has survived more attempted falsifications is the better hypothesis.

4.4.2.2 Kuhn: revolutions and paradigms

The logical positivists had a somewhat ahistorical view of science: they sought to uncover the timeless logical structure to which science should conform. Kuhn (1996), in contrast, saw science as a historically grounded phenomenon. Further, Kuhn saw science as something that changed radically over time. According to Kuhn, scientific theories vary so significantly over time that the findings and theories at one time cannot be meaningfully related to the findings and theories of other times: different theories are thus incommensurable. They constitute different languages that cannot be intertranslated. Instead of viewing the historical progression of science as the progressive accumulation of truths, Kuhn argued for a non-cumulative shift from one paradigm to the next. These changes over time conform to a cyclic pattern that can be broken down into five stages of

(1) immature science
(2) normal mature science
(3) crisis science

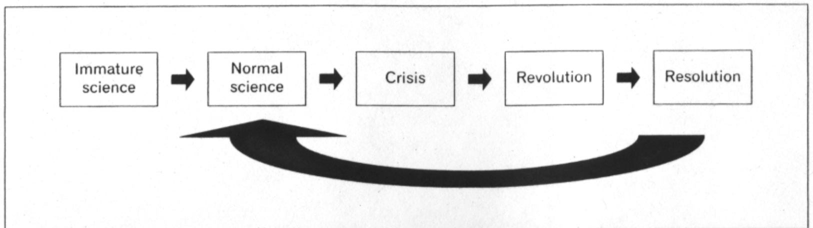

FIGURE 4.2 The cyclic structure of the historical development of science according to Kuhn

(4) revolutionary science
(5) resolutions, which is followed by a return to normal science (see Figure 4.2).

The key notion in understanding Kuhnian philosophy of science is the notion of a *paradigm*. The key stage is normal science and normal science is paradigm-based science. The remaining four of the stages are understood by way of contrast with normal science. What, precisely, a Kuhnian paradigm is supposed to be has been a matter of debate, but the following sketch will suffice.

For Kuhn (1996, p. 20), paradigms are "Universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners." Further, paradigms define what problems and methods are to count as legitimate for succeeding generations of practitioners. Paradigms accomplish these feats in virtue of two essential characteristics (p. 10): first, "Their achievement was sufficiently unprecedented to attract an enduring group of adherents away from competing modes of scientific activity." Second, their achievement "was sufficiently open-ended to leave all sorts of problems for the redefined group of practitioners to resolve." Examples of paradigms include, according to Kuhn, Ptolemaic astronomy, Copernican astronomy, Aristotelian dynamics, Newtonian dynamics, corpuscular optics, and wave optics. Arguably, behaviorism constituted a paradigm in psychology that was superseded by cognitive psychology.

Normal science is science that takes place under the guidance of a paradigm: normal science is paradigm-based science. Prior to the arrival of a paradigm, science is immature, according to Kuhn. Immature science is science studying a domain recognizably the same as that studied by paradigm-based successors, but without the utilization of any paradigms. Examples include the cases of optics prior to Newton and electrical research in the first half of the eighteenth century (Kuhn 1996, pp. 12–14). Once a paradigm takes hold, its influence is not exerted forever. A paradigm exerts its influence only as long as a relative consensus as to its applicability exists. When the consensus begins to unravel, a stage of crisis emerges. After a period of crisis, novel approaches of problem solving emerge, thus constituting a scientific revolution. The fruits of revolution are a new paradigm, returning the cycle to a stage of normal science.

According to Kuhn different paradigms are incommensurable and thus choice of one over another cannot be subject to rational procedures. We can understand the incommensurability of paradigms by analogy to different languages, the terms of which cannot be translated into each other. For instance, the term "space" as used in Newtonian physics cannot be translated as the term "space" used in Einsteinian physics. Einsteinians mean different things by "space" than do Newtonians: they use the term in different ways. Unlike Newtonians, Eisteinians hold that space is curved by mass. Kuhn buys into an account of the meaning of theoretical terms whereby the meaning of a term depends on the theory it is embedded in. Where theories diverge, so do the meaning of their terms, regardless of superficial similarities like spelling and pronunciation.

Among Kuhn's arguments that paradigms are not open to rational choice are those that concern the theory-ladenness of perception and observation (recall our discussion from Chapter 3). According to Kuhn, observation statements cannot serve as neutral points of arbitration. There is no theory-neutral observation language because how one perceives the world depends on the theory with which one conceives the world.

Kuhn argues that since paradigms are incommensurable, the history of a scientific discipline is non-cumulative. None of the discoveries and theories of an earlier paradigm can be retained by later paradigms. Thus the progress of science is not the accumulation of scientific truths. Scientists are merely changing their minds over time, not adding to an ever-increasing store of knowledge. Non-cumulativity follows from incommensurability. Since the language of one paradigm cannot be translated into the language of another, the statements held to be true with one paradigm cannot be expressed, let alone judged to be true within another. Adding the theory-ladenness of perception to the equation means that just as theories are not accumulated, neither are observations, since observations depend on theories. Kuhn's thesis of non-cumulativity challenges the traditional view of science a source of progress. Instead, science seems more analogous to changes in clothing fashion: what is valued by one generation is no better or worse than any other. People are merely changing their minds about what they like. The history of science, as viewed through the Kuhnian lens, is of a series of paradigms and revolutions, none bearing any rational relation to any other.

Philosophers and scientists have reacted strongly against many of Kuhn's claims. For instance, Kuhn's hypothesis of incommensurability has been challenged. Some have argued against the view that the meanings of theoretical terms are determined wholly by factors internal to a paradigm, but instead may be determined, at least in part, by causal relations between the term and items in the external world. Putnam (1975) suggests that the meaning of certain scientific terms involves causal relations between the terms and things in the world that they denote. For instance, part of the meaning of water is the substance H_2O that was present when the term *water* was first brought into use to denote that substance. A causal chain leads from current uses of *water* to the initial dubbing of H_2O as water. These causal chains remain constant regardless of a scientist's theory. Thus, water discourse need not be incommensurable between adherents of divergent theories about water. The debate about meaning reflected here is a conflict between internalists and externalists about representational content as discussed in the box on Cartesian skepticism and in Chapter 1 in the discussion of theories of mental representation. We will discuss this further in Chapter 6 in the discussion of the philosophy of language.

Another challenge to Kuhnian incommensurability arises from theorists who propose that the mind is modular. Recall from Chapter 3 that Fodor (1983), for example, argues that many perceptual processes are modular in the sense of being "informationally encapsulated" so that

their outputs are immune to influence by theoretical and other acquired beliefs. Fodor, therefore, contends that observational reports can be treated as univocal even when theorists hold different theories. Though, as discussed in Chapter 3, it is not clear that this solves the sorts of problems raised by Kuhn.