Cognition for Science?

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Abstract

In this review of Giere's Cognitive Models of Science 1992), underlying theoretical assumptions of cognitive models are examined from a psychological and philosophical viewpoint. In particular, the aim of the book to constitute a unified cognitive model for the sciences is addressed. The ambiguity of cognitive processes is discussed as a major problem for cognitive explanations of science theory from a Kantian point of view.

Commentary on: Giere, Ronald N. (1993) Cognitive Models of Science, Psycoloquy: 4,#56 Scientific Cognition (1)

Keywords: cognitive science, philosophy of science, cognitive models, artificial intelligence, computer science, cognitive neuroscience

1. Giere's book (1992) is based on an interesting idea. At hand is a selection of articles from cognitive science on the philosophy of science. The central idea is "that the cognitive sciences have reached a sufficient state of maturity that they can now provide a valuable resource for philosophy of science" (p. xv). The scope of the book is excellently outlined by Giere in the Precis (see Giere, 1993). He attempts to both broaden and bring systematic order to the topic of cognitive modelling by distinguishing three well-known hierarchical levels of analysis: artificial intelligence, cognitive psychology and neuroscience. As they are the most useful models, psychological approaches are selected (p. xvii), and thus the first half of the book focuses only on cognitive models in psychology. Although generally the treatments are balanced, the variability of the texts (e.g., like technical report, essay, brief overview, review) may reflect the challenge or the diversity of the approach.

2. This recent attempt to establish that a unified cognitive model for philosophy of science is possible in principle -- despite the fact that no agreement has yet been reached on the subject -- may well fail, but it may at least have the useful side effect of shedding light on the relationship between the different paradigms for science, whose mutually incompatible claims to unique or self-evident validity from time to time confound the whole enterprise of philosophy of science. The fact is that any theory in cognitive science implies a view of human nature, human knowledge, and the relationship between human and non-human reality (Dittrich, 1994), and this fact remains whether or not the cognitivist chooses to

consider the implications for philosophy. The reasoning for Giere's attempt goes more or less as follows: Concepts and judgements are products or structures of thought; thought is a cognitive process; therefore, philosophy of science is the theory of thought, and whatever pertains to the philosophy of science belongs to the domain of cognitive sciences. In so far is the line of arguments the same as in support of psychologism.

3. By and large, the problems addressed in Giere's book are traditional problems in a new guise (explicitly acknowledged by Churchland, e.g., p. 353). In fact, the conceptual apparatus of these models is surprisingly close to that of folk psychology. Having said this, it should be conceded that the old issues typically appear in new and tractable versions. For example, Carey (pp. 89-128) discusses the traditional issue about the nature of conceptual change in children and in scientists within the framework of developmental psychology. Carey argues that knowledge development, in particular the development of concepts, is a process of theory development and conceptual change. Children make sense of their experience through "intuitive theories". Later they experience inconsistencies and abandon their beliefs; at this point they restructure their experience and form new theories. Carey proposes that knowledge acquisition always brings radical conceptual change, a topic which is elaborated in other chapters as well (e.g., Nersessian, Chi, Bradshaw, Darden, Nowak & Thagard, Freedman). Hence if the reader understands the title Cognitive Models of Science as referring only to the analysis of cognitive processes, this would not cover an essential theme of the book, namely the THEORY OF MIND approach to science.

4. Carey critically discusses interesting data about children's concept of objects, in particular weight/ density and material/immaterial concepts, but a problem of analogy remains in the end. Whatever the cognitive mechanism through which children acquire new concepts is, its significance for the formation of scientific knowledge remains unclear. Can it ever be more than a pure analogy or does all concept formation involve necessarily radical conceptual change? Certainly, the latter position cannot be defended seriously (see, e.g., Barsalou, 1983; Rosch, 1978); furthermore, the possibility that Carey's results strongly depend on instruction and use of cultural knowledge cannot be ruled out either. Again, is the cognitive approach able to unite cognitive psychology and philosophy of science and specify the same principles for concept development in children and scientific knowledge acquisition?

5. The dilemma of cognitive models is that although the cognitive view does not ignore the distinctive characteristics of science and epistemology, cognition is unable to attribute these to a peculiar methodology or a specific problem space. Instead, this attribution can only be to common cognitive processes in individuals functioning within certain patterns of social organisation. For this reason, I assume, sociological or historical analysis must always accompany cognitive analysis to set the context for explaining the specific scientific achievement. For example, the cognitive ability of mental modelling alone is insufficient to explain the achievements of Faraday, Galileo or the Wright Brothers. Consequently, Nersessian labels her approach a "cognitive-historical analysis" (p.4). Certainly, science is a socially organised process of knowledge acquisition, but in the whole book I could find no arguments discussing why scientific knowledge is basically different or based on different cognitions as compared to the knowledge a sailor has of weather, a farmer of soils, or a chef of spices. In the book, the cognitive view is applied to science as just another form of knowledge, which is common to theory of

mind approaches. In this sense, cognition is applied to science in the same way it is applied to other more modest forms of knowledge. That is, science is described not as requiring specific cognitions, but simply as another domain of expert knowledge, and as such no different from expertise in chess or programming.

6. Chi (pp. 129-186) seems to assume that expertise and scientific knowledge are structured similarly, and suggests that the distinction of conceptual change between and within ontological and non-ontological categories is the key to understanding scientific thinking. This author claims that discoveries are associated with radical conceptual changes which are caused by anomalies or unexplained phenomena. Chi's procedure leading to scientific discovery, revolutions, and thinking describes nothing other than the traditional concept of empirical procedure, that is question, hypothesis, and testing. Surprisingly, while the chapter includes excellent examples from research on concept formation, it ends with a less than satisfactory conclusion: "However, physical science concepts probably cannot be understood that way." (p.181). In the traditional philosophy of science, understanding physics plays a central role in understanding science. In this respect, are we again confronted with the traditional maxim that mental activities are not the same as logical relationships, and cognitive concepts are not the same as conceptual knowledge?

7. Giere's book can also be seen as similar to a historical or social approach in the philosophy of science (e.g., Merton, 1973), with scientific concepts as the explanandum and their social, political or economical context as the explanans. In this book, social data are replaced by or supplemented with cognitive processes as the explanations, supported by empirical facts about cognition. This is in contrast to pure rational thoughts, which are often qualified as metaphysical fictions. In this sense, Giere's proposal that cognitive science has begun to have considerable impact on the content and methods of philosophy (p. xvi) is correct, although he seems to ignore the fact that from the beginning of the philosophy of science, there has been a tradition which used the "intellectual history", and the extent to which concepts were shared by the members of social groups, as genuine sources for models about science (e.g., historiographic approach to mental products -- Krieger, 1973; Lindenfeld, 1988). If psychological factors were explicitly analysed in these approaches, the analysis was restricted to motivational and emotional factors and their importance for the acceptance or construction of scientific theories.

8. This book can be interpreted as an extension of such approaches because it is concentrated more on mental processes rather than motivational or social ones. Nevertheless, its arguments are constructed within the same framework as the historical school in philosophy of science. Therefore, it is not surprising that Thomas Kuhn is cited more often than any other author, his work being cited at least thirty-two times in this book. The only difference between the cognitive and historical approach seems to be that a cognitive model of science is again based on a traditional theme in western philosophy, namely, the dominance of cognition over action. That is, cognitions or individual concept formation in science are dominant over the patterns of scientific communication or the notion of science as mainly social construct. An excellent summary about approaches which analyse the normative and justificatory aspects of science in terms of descriptive and empirical investigations can be found in Fuller's chapter "Epistemology radically naturalized" (pp. 427-459). However, his own approach, which he describes as

experimental social epistemology, is argued less convincingly. Experimentation and social analyses are often seen as contradictory approaches, and both combined within an epistemological framework would normally lead to a highly indigestible mix. This chapter nevertheless includes some amazing ideas, for example, the introduction of Clausewitz's terminology into the discussion about cognitive and social factors of science.

9. In the book the cognitive models are equivalent to reductionist models because science is analysed as brain activity, be it on the psychological or the neurocomputational level (Churchland, pp. 341-363). In this sense, such a conception of cognitive models is close to Hume's bundle theory of the self. Alternatively, in Kant's view, cognitive processes may describe necessary conditions for the possibility of scientific thoughts, in so far as "mental concepts" are required for the formation of scientific theories, but they are not sufficient to explain the content of a scientific concept. Can the probability of scientific truth be inferred from the mechanics of our mind? Or is it, as Kant suggested, the transient nature of cognitions which make them inappropriate to qualify as the basis for necessary and reproducible judgements about the external world? Judgements are statements one is conscious of, whereas cognitions need not involve conscious processing. However, besides the temporal instability of cognitive structures, it is also their haziness or fuzzy boundaries that give rise to doubt that cognitions can form the corner-stones of a new philosophy of science. Scientific knowledge is sharply defined in so far as it is discrete or separate from other concepts, but the world exists as a continuous flow of information and reality has no sharp boundaries. Thus, the problem of the relationship between mental processes and scientific knowledge can be described as a special case of generating discrete structures (i.e., concepts) by means of continuous ones (i.e., cognitions). One could argue that the cognitive models described in this book address the issue of how boundaries are found, but leave untouched the question of who actually decides where the boundaries are. That means: Are cognitive models of science dependent on a decision maker or homunculus in our mind?

10. In my opinion, the strengths of Giere's book are its informal and engaging style (e.g., Nersessian, Bradshaw, Nowak & Thagard, and Churchland), but this is also its weakness, because more clarity or consistency in using common terms and constructs (e.g., representation, concepts, theory) across different chapters would be necessary if the aim is to form a unified cognitive approach. In particular, cognitive scientists promote the idea that there is no way to understand language or cognition apart from communication. In the eagerness to arrive at a unitary view of cognition, however, there is an extensive reshuffling between the boundaries of traditional disciplines. For example, it seems a mystery why Bradshaw's most informative, but sociological account of the Wright Brothers' invention is categorised as a model from Artificial Intelligence. Overall, the book is well edited and the subject index and list of contributors are both very useful. In my view, the excellent quality of publishing should be commended. However, I found it particularly surprising that the first volume of this series, Minnesota Studies in the Philosophy of Science, edited by Feigl & Scriven (1956), which addressed the same topic, Foundations of Science and Concepts of Psychology, is not cited once in Giere's book. Can this be interpreted as indicative of a shift in paradigms, or is cognition so occupied with itself that earlier mental products become pure history?

11. Despite these reservations, this book is well worth reading, though the great diversity of the

approaches made an overall synthesis difficult. In my view, there are serious doubts as to whether the conclusions contained in the chapters actually "permit the philosophy of science finally to move beyond the diversion between 'logical' and 'historical' approaches" (p.xv). However, the book could be used successfully as an advanced text to exemplify the achievements and limitations of cognitive models of science. Without a doubt, more than advancing the philosophy of science, the book serves as a fine demonstration of Piaget's (1979) conclusion: "Psychology occupies a key position in the family of sciences in that it depends upon each of the others, to different degrees, and in turn it illuminates them all in distinct ways."

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