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Book Review

The Cognitive Basis of Science Edited by Peter Carruthers, Stephen Stich and Michael Siegal. Cambridge University Press, 2002. Pp xii+409.

Reviewed by Fredrik Stjernberg

It is a commonplace that there are historical and cultural factors that have precipitated the development of science; not all cultures have engaged in science. It is also, or should at least be, a kind of commonplace that there are cognitive factors that have been of importance; not all sentient creatures have engaged in science. But every move beyond these commonalities immediately gets us into deeper waters. Which cognitive factors have been important? What should we count as science? What is the difference between on the one hand the unschooled mind of children or of our everyday attempts at understanding the world, and on the other hand the sophisticated attempts of scientists to frame and test hypotheses and theories?

These, and many other, questions are the topics for this rich and well-organized volume, originating in a series of conferences held at Rutgers University and Sheffield University. It contains 18 contributions by 25 authors. In this review, I will not deal with each and every contribution; such a review would either be much too long, or much too sketchy. Rather, I will focus on common themes and questions that concern the general thrust of the papers. All in all, the papers are of a very high standard. The area of interest for the contributors to this volume is very large; results, theories and ideas from widely different areas are relevant for their work. They draw on work in philosophy, developmental psychology, social psychology, neurology, cognitive psychology, biology, and perhaps a dozen other disciplines.

There is much here for further work – many papers are to a high extent inspiring reports of work in progress. Collectively, the papers make a significant contribution to our understanding of science and cognition. The papers are in four sections: Science and innateness, Science and cognition, Science and motivation, Science and the social.

Science and innateness

Man is unique in having science. But science as we know it has only existed for the last few hundred years, and not in all societies. Therefore, the ability to do science cannot be completely grounded in the biology of our species; as humans we have gotten along reasonably well without it for the greater part of the existence of mankind. But on the other hand, it has been difficult to understand exactly how science could have evolved, unless we had some innate mechanisms for something like science. Yet advanced science seems so alien to most things that matter for ordinary human concerns. So how could we have developed science? The problem has been put forward by Chomsky: ”The experience that shaped the course of evolution offers no hint of the problems to be faced in the sciences, and the ability to solve these problems could hardly have been a factor in evolution.” (Chomsky, *Language and Problems of Knowledge*, p. 188; quoted by Atran, p. 41). The contributions to this first section function as a response to Chomsky’s challenge.

Could what we now know as science still have its roots in factors that are recognizably present in all humans, perhaps even from childhood, or factors that were salient in human prehistory? In the last few years, the hypothesis of the ”scientist in the crib”, or the ”baby in the lab-coat”, to a large extent associated with Alison Gopnik, has gained some acceptance. According to this hypothesis, advanced science is simply what children do naturally in their cognitive development, but there is no principled difference between childhood and full-blown science. (Several papers in the later sections also deal with this hypothesis, especially the very last paper, by Faucher et al., which criticizes the idea.)

The contributors to this section provide a few different views on these issues, trying to meet Chomsky’s challenges by indicating similarities and parallels between pre-scientific behaviour and fully developed science, such as tracking behaviour (Carruthers), folk biology (Atran). Evolutionary factors in the development of science (Mithen).

Carruthers examines the idea that science as we know it actually could have evolved gradually, as a result of evolutionary pressures that are recognizably present in pre-scientific societies, factors that can be traced back to human prehistory. One skill that was vital for these people was *tracking*, and Carruthers cites several studies of which cognitive skills, and more or less science-like mechanisms, that are involved in tracking. There is a need for constructing hypotheses about the unobserved animals that have caused the tracks, and Carruthers concludes that “anyone having a capacity for sophisticated tracking will also have the basic cognitive wherewithal to engage in science.” (p. 83) And since the actual tracking practices of hunter-gatherers turn out to be remarkably sophisticated, the remaining differences will be more superficial or extrinsic: “the cognitive processes of hunter-gatherers and modern scientists are broadly continuous with one another” (ibid.).

Mithen concludes that ”the cognitive foundations for science emerged ... piecemeal over at least 5 million years.” (p. 40) He describes the various steps that would have to be taken by our hominid precursors, and this at the same time becomes a catalogue of what cognitive factors we, today, need in order to do science. He suggests that all the cognitive factors should have been in place at the end of the last Ice Age (ibid.), an assessment which concurs with that of Carruthers, quoted above. And the rest is presumably history, or based on social factors, for which mankind had to wait a few thousand years. Such social factors include for instance the invention of instruments and a class of people that are reasonably well off, and have time to pursue their interests.

Science and cognition

Not unexpectedly, this is the largest section, with seven papers. Rosemary Varley’s paper, ”Science without grammar: scientific reasoning in severe agrammatic aphasia” reports experiments and observations indicating that people can understand and do a fair (surprisingly large) amount of science while being severely impaired linguistically. These findings would indicate that understanding of science is not as intricately bound up with language skills as many would have us believe; scientific reasoning is at least to some extent independent of the use of language. Perhaps there could even be some modules for aspects of scientific understanding. The subjects studied by Varley show some specific reasoning skills, such as some theory of mind reasoning, causal understanding and conditional reasoning involved in hypothesis testing (p. 114).

Since the subjects studied became aphasic as adults, there still remains the question whether the aphasic subjects could have *acquired* their understanding of science without a functioning language, but the results still point to an interesting degree of independence between the two systems (if “system” is the correct word for something as large and many-faceted as science – the idea that there is *one* “science module” would not be worth taking seriously).

Nancy Nersessian’s paper, “The cognitive basis of model-based reasoning in science", sheds some new light on the issue how creativity in science might work, how scientist might arrive at genuinely novel ideas, given that they are forced to start with existing ideas.

In Nersessian’s, as well as in Dunbar’s contribution, “Understanding the role of cognition in science: the *Science as Category* framework”, there is an interest in how scientists actually go about doing whatever it is that they do. Dunbar and his associates have studied researchers in different cultures, trying to find out whether there are specific differences between their modes of reasoning, even if they are active in the same discipline. Northern American scientists tended to use inductive reasoning more often than the Italians that were studied; the latter group used deductive patterns of reasoning instead. These findings are supported by Faucher et al., who cite several studies indicating differences in reasoning patterns between American and Asian subjects. Central to Dunbar’s work is the *science in vivo* method, where actual scientists are followed closely at lab meetings. Their results are then used in developing the “Science as Category” framework (pp. 164ff). This framework stresses that scientists use cognitive building blocks that are common to many other things human beings do in other areas (ibid.). The special thing about science is that science has other goals and combines the cognitive building blocks in other ways.

Evans’s paper, “The influence of prior belief on scientific thinking” is connected with this. What is the special goal of science? Presumably getting at the truth. But in that case, how are non-cognitive, not truth-conducive, factors relevant? It is shown that our prior beliefs have a vital role to play in our coming to hold a theory true, and these beliefs can concern many things that are not exclusively truth-conducive, such as beliefs about the “argumentative skills, status and influence” of the persons proposing a certain theory (p. 201).

Science and motivation

Scientists are usually highly motivated in their daily work. But which factors are of importance, and how do such factors work in relation to the distinction between the context of discovery and the context of justification? The more traditional view has been that aspects of motivation have been important for the context of discovery – wanting to win a Nobel Prize can be vital for getting people to do research – but should they have a place in the *justification* of theories as well? In line with recent work on motivation and the emotions, several writers in this volume argue that the actual justification of scientific theories is thoroughly interwoven with motivational factors, and not just that emotions can matter for making a scientist want to pursue a certain train of thought.

Thagard’s paper, “The passionate scientist” discusses how factors such as the individual scientist’s assessments of the beauty of a theory (which would appear to be an aesthetic, non-cognitive, assessment) is crucial for the acceptance of that theory. A “coherence theory of inference”, drawing on earlier work by Thagard and Shelley, is described, and extended to encompass emotional judgements: overall coherence is what the subject strives for in drawing inferences, and the emotional element, being liked or disliked, plays a role here (p. 245). There will also be no emotion-free concept of coherent inference that could work in practice.

Kitcher’s paper, “Social psychology and the theory of science”, concerns the economics of science. Trying to get a Nobel Prize can do wonders for some scientists, while others can be – and usually are – moved by completely different things. Kitcher shows how “(m)undane motivations may sometimes work beautifully in the collective discovery of truth." (p. 264). Kitcher gives this claim some rigour by putting idealized, but reasonable, values on the probabilities and expected utilities of different strategies in the search for truth.

Science and the social

Science is not only a cognitive phenomenon; as attested by several of the earlier contributions, social factors are important as well. If we accept Mithen's claim that all the cognitive essentials for science were in place several thousand years ago, why didn't science start much earlier? A reasonable assessment suggests that science as we know and recognize it started roughly 500 years ago. What happened then, or perhaps, what didn't happen much earlier? External factors have been suggested: new instruments, people with a sufficient amount of leisure, and yet others.

But to say this need not lead to social constructivism. In what ways can the undeniably social aspects of scientific research, as it really is done, best be described? How can science be *both* socially grounded and a means of finding out the truth about the world?

Giere's paper, "Scientific cognition as distributed cognition", concerns a special feature of science, compared with other kinds of knowledge: its *extended* nature. Science is an ongoing collective undertaking, and what is known in science cannot be equated be what individual scientists know without the aid of other scientists or even of the instruments and technical apparatus used in arriving at the theory. There is no non-arbitrary way to draw the line between the individual scientist's mind and the instruments that are necessary for conducting research, if we want to say things about what knowledge of a scientific theory consists in. Science is a form of distributed cognition, and this will lead to blurring the distinction between the cognitive and the social (p. 296).

Another important social factor is that we learn things from others; perhaps the greater part of the things I know are things I have learned from others. How do children learn things from others, and how is scientific knowledge related to the way in which children learn things? The last three papers, by Siegal, Harris, Faucher et al., consider these issues from various perspectives.

This book could be the starting point for a significant change in how we think about science.

Traditionally, the philosophy of science has been unrealistic in a few ways. It has held a too abstract, idealized and individualist view of what science is. Various attempts have been made by historians and sociologists of science to correct this picture, but their efforts have paved the way for a social constructivist view of science, which in its turn usually fails completely in capturing what is special about science; on this view, changes in scientific theories are not that different from changes in fashion. Science is both a cognitive venture, aiming at truth, and a social activity, located in a historical and cultural setting. This has been realized for quite some time – perhaps ever since people first started thinking about these things, but it has been remarkably hard to give both these views their right weight. Philosophy of science has been locked in a kind of oscillation between two unrealistic extremes. This collection could provide some impetus for giving both factors the right weight.

All in all, this is a very impressive collection. The individual contributions are of a high quality, and collectively they indicate the importance of factors from many different areas in understanding the complex phenomenon that is science. Everyone with a serious interest in the philosophy of science will find much of value here.

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