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Rationality in discovery

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Chapter 2

Rationality

2.1 Introduction

What is the rational use of theory and experiment in scientific discovery, in theory? In pursuing an answer to this problem in this thesis I use ideas from cognitive psychology to look at issues about the rationality of science that are traditionally part of the problems of the philosophy of science. As an introduction to that approach I will argue in this chapter how ideas from cognitive psychology can make a sensible contribution to debates about rationality in philosophy of science. I will make this point clear by explicating some relations between assumptions in cognitive psychology and issues in the philosophy of science. Hence, the particular question in this chapter is: how can cognitive psychology contribute to the discussion about the rationality of science in the philosophy of science? As an introduction to this chapter I first want to tell a parable about an intriguing family.

Prelude

This tale begins in the seventeenth century, in the days of the first great achievements of an ambitious young child of Mother Philosophy. In his time this aspiring infant developed a successful new style of understanding the world by tampering with it. He and his family became known as Experimental Philosophy.

Eventually he left the skirts of proud Mother Philosophy as an independent adolescent named Science. He set out to find answers to millennia old questions of the Philosophy family in a way that proved successful: with the method of empirical experiment and with the aid of the rigidity of his other parent, Father Mathematics. Science had an older brother who was fascinated by his younger brother's doings. When Science left Mother Philosophy his older brother stayed safely with his mother. Today the family of this son is called: Philosophy of Science.

At the end of the nineteenth century Mother Philosophy gave birth to a startling bright son from Father Mathematics. He was nurtured and raised by his brothers Philosophy of Mind and Philosophy of Language. With a few growing pains it reached maturity very quickly. The career of this son looked really promising. He begot the name Modern Logic. The Philosophy of Science family was very impressed by the capacity of this new sibling. Especially Positivism, a relatively young member of the Philosophy of Science family, was delighted.

At a certain moment in the beginning of the twentieth century, Positivism with the aid of Modern Logic declared it was time to completely break with one of Mother Philosophy's traditions. He thought that his admired brother Science had proved that the ideas of Mother Philosophy that were not empirical were irrelevant for answering Science's questions. All questions worth considering should be questions only Science could answer. And all theories of Science should be certain. Positivism would try to achieve this through the interpretation of the language of Science with the tools of his brilliant young brother Modern Logic. No wonder, he became known as Logical Positivism.

First this offspring of Philosophy of Science was warmly welcomed and embraced by old brother Science. It looked as if he opened up the possibility that the activities of Science would finally provide certainty, without being bothered by the problems and questions of Mother Philosophy that could not be solved empirically. Determined Logical Positivism would give Science a totally empirical and mathematical guideline and justification for his actions, in the true spirit of Science himself.

Yet the claims of Logical Positivism did not last very long without reaction of his brothers. Rationalism, another smart protégé of Philosophy of Science, showed, also with the help of his brother Modern Logic, that Logical Positivism's method of justification of the actions of Science was logically incorrect and he replaced it with an alternative. With this other method of Modern Logic as his standard he enforced the claims of the family of Realism, another son of Philosophy of Science. Logical Positivism felt defeated and eventually retreated from his too optimistic ideas.

Meanwhile, Science himself did not leave it with that. He took the discussion to his own domain to study the problems further. Science set out to empirically investigate his own activities and successes, those of that day and those of the glorious past. By empirically studying their own behavior, a member of the family of Science, Social Science, examined how the Sciences had actually behaved and tried to find out why they had done it in that way.

An astonishing conclusion seemed that a fully rational justification and explanation of Science's action and success seemed not possible. It appeared that beliefs of the members of the Science family were not rationally determined but socially. It seemed to have nothing to do with truth, the hallmark of Mother Philosophy as well as that of old Science. But, ironically enough, the truth of that conclusion implied that that conclusion could not be justified as true either. This was honey for the taste of a black sheep of the Philosophy of Science family: Relativism. According to him truth was impossible to achieve by Philosophy as well as by Science.

But the noble children of Philosophy of Science soon recovered from the apparent blow dealt to them by this relativistic conclusion. They put forward competing theories of rational justification of the activity of Science and tried to live up to Science's empirical standards.

Realism refined his ideas and, with the help of Modern Logic, delivered a rational justification of the data of Social Science, interpreted as steps toward the truth. Pragmatism, another member of the Philosophy of Science family, sought a way in the middle. He put forward a justification of the behavior of Science as rational, with not truth but just the solving of problems as his goal.

Looking in perspective to the quarrel among the Philosophy of Science family about the career of their successful brother Science we see so far the following: Logi-

cal Positivism tried to provide a justification of the results of Science's activities with the help of the formal language of Modern Logic, in which the Science family could represent their theories rigidly. Realism agitated against this by rejecting Logical Positivism's ideas about method and justification and put forward another method and way of justification, based also on Modern Logic, in its place. With the help of an empirical investigation of Science, Relativism reacted to Realism by showing that Science did not and never had acted according to Realism's rational method based on Modern Logic. From this it would follow that the doings of Science could not be explained rationally in this way. Realism refined his rational theory of justification showing that it could fit in with Science's empirical data. Next to that, Pragmatism developed another justification of Science's deeds by characterizing rationality as practical problem solving instead of looking for truth.

In the meantime, before Social Science studied the behavior of the members of his family as a group, other members of the Science family had not relinquished their attention to the subjects of behavior and rationality. Illuminated by the views of Logical Positivism, Behaviorism, a pretentious newborn of Science, studied behavior according to Positivism's methods and tried to keep rationality out of his theories. But Behaviorism disappeared to the back stage shortly after the rationalistic defeat of Logical Positivism. In his place came Cognitive Psychology, a new protégé of Science, who set out to explain behavior as a result of rationality. He did this with the help of new developments of Modern Logic and with the use of empirical methods. This ambitious child of Modern Logic and Science gave rise to a new style of thought for Philosophy of Mind. His family got the name Cognitive Science.

Until fairly recently the development of the family of Cognitive Science is looked at by Philosophy of Science as mainly another Science to be considered true, relative, practical or just nonsense according to some style of justification. Yet, Cognitive Science had the ambition of explaining the whole notion of belief and reasoning by his empirical examination of thought, rationality, the brain and behavior. Among other studies he did so by the exploration of Science's presumed mental processes during the process of discovery. He got precious help from Uncle Technology together with the ideas of the daughters and sons of noble Modern Logic and Science: Computer Science. Today Cognitive Science is supported with its work by a great part of the Science family.

I now come close to the moral of this introductory story. When we return to the entanglements of the Philosophy of Science family we noticed that at one point the relation between today's Science and Philosophy of Science turned around. Scientific results justified the claims of a Philosophy of Science instead of, in the traditional way, the other way around.

So, I ask: why shouldn't Cognitive Science contribute to Philosophy of Science's family discussions about rationality, reality and truth just as well as Social Science does? For the family of Science as well as for the family of Philosophy of Science it is probably insightful and productive if both directions are explored, possibly to result in a better relationship of understanding between the families...

Overview

In this chapter I discuss how ideas from cognitive psychology could be relevant in the domain of philosophy of science and where they would clash. After that I look the other way around, showing that cognitive psychology addresses topics relevant for philosophy of science that are usually not addressed in the mainstream.

In Section 2.2 I sketch some main issues in the philosophy of science, briefly rehearsing the ideas of several philosophers who made influential contributions to the field: Carnap, Popper, Kuhn, Lakatos, Laudan and Hacking, followed, in Section 2.3 by Jerry Fodor's thesis about the language of thought, a paradigmatic theory in cognitive science.

Then, in Section 2.4 I will consider the appropriateness and possibility of a contribution from the viewpoint of Fodor's cognitive psychology to the issues of rational justification, theory development, representation and the explanation of behavior. I will argue that if Fodor's thesis is accepted, no relevant form of relativism is tenable. His thesis provides a rich framework for considering theories about reasoning in a scientific context.

Following that, in Section 2.5, I shall argue that cognitive psychology can do more than that. It also makes possible a theory about discovery and it shows a relation with discovery as problem solving and the justification of theories. As a result of that, I will argue that the framework of cognitive psychology is rich enough to provide an adequate explanation of the development of scientific theories. In Section 2.6 I conclude this chapter with an evaluation of this chapter's claim, that accepting a theory about science is accepting a theory about the mind and vice versa.

2.2 Philosophy

There are many ways to look at science from a philosophical stance. There are probably just as many ways to describe existing philosophies of science. For that reason, as a guideline for this section I use the ideas of some of the important contributors to the field that is called philosophy of science. I follow four general issues in the work of these philosophers: theories about the justification of theories; the development of theories; what theories represent; and finally the actual practice of scientists. This line of description probably does not do complete justice to the initial intentions of these philosophers but is still useful for a short overview in the light of the goal of this chapter.

Carnap

After the sudden flourishing of theories in logic at the end of the last century, philosophy of science became focused on theories about language. Fast developments in logic provided formal languages with the aim to interpret propositions non-ambiguously. If it would be possible to interpret all theories of science in a formal language then the meaning of those theories would be reduced to the relation of the formal language and the world. This assumption gave rise logical positivism.

The main question became: what should or does language represent? Rudolf Carnap (Carnap, 1967) defended the following idea: all that a scientific theory should represent were terms and propositions whereof the truth could be confirmed in reality. The meaning of a proposition should be its way of verification.

Theory development should be a process of putting theories forward and confirming them. When universal statements were constantly confirmed they were justified by induction: justification of the general by the special. All scientific questions should be answered in this way to have any meaning at all. Questions which could only have answers that could not be confirmed should be dispelled from the domain of science. Theoretical terms of theories should be translatable into observational terms to be allowed in a scientific theory. Causes, unobservable entities, untestable hypotheses were all considered to belong to metaphysics and should have no place in a decent philosophy of science.

Popper

A philosopher who agitated most strongly against the logical positivism of Rudolf Carnap was Karl Popper. In his famous book 'The Logic of Scientific Discovery' (Popper, 1959, first published as 'Logik der Forschung' in 1934), he reacted with a logical critique against Carnap's ideas about representation, theory development and justification. He argued that confirmation as justification of universal statements is not tenable. A theory could be confirmed many times and still be false. For a theory to have any value it should be possible to refute it deductively.

Popper defended this notion as a way to demarcate true science from pseudo-science: a rational criterion of demarcation. The more sorts of experiment a theory allows to test it with, the more empirical content it has. The more falsifying tests it survives the more it is corroborated. A theory can never be accepted as true but only be found false as one accepts a refuting singular statement or otherwise be highly corroborated as one has come to accept many singular statements that support it.

The method of doing science should be to put theories forward and then to try to falsify them. When a theory is falsified it should not be repaired with ad hoc hypotheses. Only in this way, which became known as critical rationalism, could science produce justified knowledge about the world.

Just as the logical positivists, Popper thought that the discovery of theories was not a matter of logic. For understanding the logic of science it did not matter how a theory or law was discovered. That should be the concern of psychology. It did matter whether a theory could be tested and evaluated. That was purely a matter of logic, certainly not of psychology.

The only logic to discovery is that it can be validly discovered that a theory is false if a prediction of that theory is found to be false. So Popper's book could just as well be titled 'The Logic of Scientific Evaluation' because as far as Popper is concerned in his book, there is no logic of scientific discovery.

Kuhn

Thomas Kuhn looks at science from another perspective (Kuhn, 1970). Instead of thinking about what scientific theories should look like and how they should be developed, he empirically and historically investigated what the actual practice of Science did look like and had looked like.

What became clear to Kuhn was that scientists do not throw away their theories when they encounter a refuting counterinstance. They stick to them as long as possible. He noticed that science knows periods of normal science, in which puzzles are solved within the borders of a theoretical paradigm, next to periods of revolution. During a revolution the old theoretical paradigm is substituted by a new paradigm with different theoretical presumptions.

These historical and sociological facts looked nothing like Popper's story about the rational criticism of falsification. Most theories are born refuted and nevertheless function as the theoretical assumptions within paradigms. And when a new paradigm is accepted it looks as if there is no rational ground for it that has anything to do with the truth of the theories in the paradigms. So, real scientific practice seemed nothing like a rational affair in Popper's sense.

According to this fact it was argued that the meaning of the terms of a theory changed radically even if the same names were used in the new paradigm. That made 'truth' relative to a paradigm, what implied that there is no progress in science but merely succession. For, how can a paradigm say anything truthfully about the world when it is a matter of time for it to be rejected and succeeded by a radically new one?

So in sum, from empirical research in sociology and historical analysis of scientific development it follows that if 'truth' is regarded as a feature of a theory which is not falsified, and 'scientific rationality' amounts to rejecting a theory as soon as a falsification occurs, then science has nothing to do with truth and scientific practice has nothing to do with rationality. It was thought that beliefs are socially determined, not rationally, dependent on scientists' authority and social influences.

Lakatos

Imre Lakatos was strongly opposed to this irrational and relativistic picture of science (Lakatos, 1978). He built on Popper's ideas trying to show that they could be made consistent with the empirical data of the historical and social studies. He elucidated the activity of science not as the project of trying to refute one theory but as investigating empirical phenomena within the theoretical frame of a research program.

A research program consists of a theoretical core which is protected by a belt of auxiliary hypotheses. When a seemingly refuting instance is encountered an auxiliary hypothesis should be reconsidered, not the theoretical hard core of the research program. So in this way it can be explained why a theory does not get abandoned after falsification: one diverts the falsification to a protective auxiliary hypothesis. A revolution is explained as a change in the theoretical hard core.

What makes Lakatos' research programs really different from Kuhn's paradigms is that there is a rational way of determining when to give up on a particular theory. Lakatos evaluates progression in theory development on the basis of the increase of empirical content. The empirical content of a theory contains the possible models of a domain that are excluded by that theory: the higher the content, the more tests are possible to refute the theory. When a theory stops incorporating new facts, the program can be considered as degenerating. It then can be abandoned for any theory that does succeed in explaining those facts. So with this account it is possible to defend a notion of truth next to a rational justification of scientific theories and practice.

Laudan

In contrast to Lakatos' realism and research programs stands Larry Laudan's pragmatism and notion of research traditions (Laudan, 1978). A relevant difference with Lakatos' research programs is that, not the empirical content but a research tradition's ability to solve problems is central for the tradition's progress.

A theory is not considered as good at solving problems when it is progressive but the other way around: it is progressive when it is good at solving problems. Those problems range from logical inconsistencies and empirical problems to conceptual differences in the worldviews of scientists.

The rational choice between two theories in this way is for the theory which solves most problems. A notion of truth is not considered as relevant to judge scientific activity as rational. In this way scientific theories, and especially terms about non-observable entities within them, do not have to say anything about reality at all to be successful.

Hacking

Ian Hacking takes a different approach in the debate about truth (Hacking, 1983). He emphasizes the relevance of the practice of experiments in science. He argues that the philosophy of science is too much concerned with theory.

He accepts the reality of some theoretical entities but without accepting that a theory that explains a phenomenon must be true. You could establish the existence of, for example, electrons by doing intervening experiments, which result should be seen apart from the question whether the theory you test about electrons says anything true about reality. But from a rationalist viewpoint you can see the ability of intervention as just a disguised form of rational justification: accept a theoretical entity when it explains phenomena during intervening experiments.

Summary

You could frame the above theories about science as consisting of an opinion about: the behavior of scientists, their organization and their acts of adhering to or working on the basis of some scientific theory; what a theory represents, in other words its relation with reality; how a theory develops; and finally, how a theory is justified. So I can give the following summary.

In Carnap's view, a theory about science is first of all a theory about representation. All possible theories of science should exist of terms which refer to the observable world. Theories that are repeatedly confirmed are justified by induction. For Popper not all terms of a theory have to be observational. A theory that explains a phenomenon must be falsifiable through an experimental result that is implied by the theory. You can justify a theory rationally if it is not (yet) falsified. Kuhn stresses the presence of paradigms and revolutionary changes in science, implying that a theory never represents anything truthfully about the world that can be defended by Popper's critical rationalism. Lakatos tries to save truth by seeing theory development as research programs with an inviolable theoretical core that is protected by a belt of auxiliary hypotheses. A research program can rationally be abandoned when it stops explaining new facts while another research program can. Laudan's research traditions are considered progressive when they solve many and new problems, which is their goal and not the pursuit of truth. Finally, Hacking sees the truth of theories as a ques-

tion other than that of the existence of theoretical entities, the latter can be established by explaining phenomena during intervening experiments by their most likely cause.

What all philosophers in this tradition have in common is that they do not attempt a further clarification of the role of processes of the mind of persons involved in science. Popper rejects psychologism, yet a form of psychologism that is based on psychological behaviorism. Kuhn embraces a psychology that implies multi-rationality but does not explain how it does so. Lakatos argues about why and when psychology could or should not interfere with the explanation of science, but he judges rationality irrelevant for it. For Laudan, science is problem solving. But he does not tell how that process comes about. Hacking also does not address the role of the mind in science (at least, not in the literature I reviewed).

In the following section I will explicate a general idea about cognitive psychology of Jerry Fodor's. It provides a framework for explaining and empirically investigating rationality in cognitive process. In Sections 2.4 and 2.5, the relevance of such a framework for the above ideas about science will be discussed.

2.3 Psychology

In this section I describe the general frame of assumptions Fodor's about cognitive psychology which is representative of the symbolic approaches in cognitive science. Fodor is a philosopher who contemplated that fundamental assumptions of cognitive psychology. In chapter 5 I will discuss work of the psychologist John Anderson, who aims to provide explanations for empirical data from psychological experiments.

One could characterize the program of cognitive psychology as looking for an explanation of intentional human behavior. The program grew out of the failure of behaviorism to explain the total scope of behavior, humans as well as animals, as a function of the environment. Cognitive psychology postulated again beliefs and desires in the organism in order to explain behavior that was judged intentional. The notions of logic and computation became recognized as a new way to accurately study language and thought. The mind of human beings was to be understood as a symbol manipulation system that governed all aspects that had made humans rational. Empirical data about complex behavior, thought and language could all be explained as the result of a process of symbolic computation that somehow should take place within the brain. .

What is now generally assumed in the program of cognitive science, is that cognitive processes of higher organisms should be seen as computational. Cognitive (or, as it is also called: computational) psychology made it possible to study language and the processes of thought with mathematical precision.

First of all, cognitive psychology is a research program to explain intentional behavior. Behavior patterns are explained as directed to a certain goal, governed by propositional attitudes: beliefs and desires. An action is caused by a desire to reach a goal together with a belief of the organism that the goal could be reached by producing that action, the relation between attitudes and action being rational and intentional. One thought of these relations as being matched by unconscious computational relations between symbols in the mind/brain.

In this light the process of reasoning could be looked upon – and empirically studied – as a process of problem solving: searching through a space of possible solutions. It turned out that this search process could be successfully analyzed as a series of computational operations on the organism's beliefs, resulting in a process of accepting and rejecting different beliefs.

Fodor

In 1975, Jerry Fodor's book 'The Language of Thought' (Fodor, 1975) marked a basis for the research program of cognitive psychology. The main idea was that the processes of the mind should be seen as computational processes. However, computation presupposes a representational system. A controversial thesis of Fodor claimed that every human being is born with a representational system that is basically the same for every human being. This system should be seen as a descriptive language. Within this representational system computational operations preserve properties of beliefs such as truth and reference.

Fodor put forward three empirical arguments to support this claim. The first pointed out that there is a semantic parallel between thoughts and sentences. The meaning of words can be compared with the meaning of mental concepts and sentences can be compared with thoughts. The second argument stressed the syntactic parallel between language and thought. Thoughts as well as sentences are productive and systematic. There are indefinitely many and complex types of possible sentences based on a lexicon and a syntax. The same holds for thought with a conceptual lexicon and mental rules.

The third and most important argument is the processing argument. Fodor argued that the learning of concepts is only conceivable as a process of inductive extrapolation: the formation and confirmation of hypotheses. So the learner must have a representational system that is capable of expressing the hypothesis before learning. And once concepts are learned the representational system is needed to consider and judge possibilities when it comes to a rational choice. Fodor further argues that perception is only possible if several hypotheses are considered to identify what is seen, because recognition of objects in the world is underdetermined by the raw data received by the senses.

These arguments led Fodor to the controversial conclusion that the only conceivable way of learning and using language was by already having some representational system or knowing some language: the language of thought. By further analysis of linguistic and psychological data, Fodor tried to show that the language of thought is at least as rich as any natural language. That implied that seemingly all basic concepts are hardwired in the brain. During youth we would learn to translate them into a culturally induced natural language. So, by studying language and its use empirically, we could find out the structure and operations of the language of thought.

Summary

To summarize Fodor's thesis: a part of human behavior is considered as intentional. Cognitive psychology provides an explanation of intentional behavior as governed by propositional attitudes, *i.e.* beliefs and desires. Part of the beliefs are reached by the process of reasoning. Reasoning is explained as a computational process in a representational system. All human beings are born with the same basic representational

system: the language of thought. Learning is a process of forming hypotheses and confirmation within that representational system. Rationality in thinking and behavior can be seen as problem solving: a heuristically guided search through a space of possible solutions.

Today, in cognitive science, Fodor's overall thesis is criticized as well as cherished. While knowing that Fodor's ideas are open to and under criticism that I have not mentioned, I still think that they show that theories in cognitive science have implications for theories in the philosophy of science. In the succeeding section I will show that the framework of cognitive psychology is rich enough to incorporate issues of philosophy of science, as set out in section 2.2. In section 2.5, I will argue that the framework is even richer.

2.4 Interaction

In section 2.2, I interpreted the theories of some important philosophers of science as being primarily concerned with justification of scientific theories and activities. In later discussions in philosophy of science the actual practice and behavior of scientists is considered as well. It is sociologically and historically studied what theories were accepted and developed and for what reasons. This empirical work resulted in data that were not consistent with the earlier logical notions of rationality.

Later philosophers tried to show how theories about rationality could still be consistent with sociological and historical data. As a consequence, they put forward different ideas about how science develops and what the resulting theories represent, if they represent anything at all, and if or how they should be justified.

Many philosophers of science who take science as a rational business take psychology as incompetent to say anything about it. Psychologically explanations of behavior should have nothing to say about how to do science rationally. But cognitive psychology not only allows rationality as an explanation of behavior, it also explicitly studies it. It even has the potential to explain notions of rationality that are normally considered the concern of modern logic.

Yet, it could be argued that what philosophy of science should contemplate about is how to reason according to modern logic, not how people actually reason. However, since Kuhn, philosophy of science cannot leave out science's practice without inviting the argument that philosophy of science, in that case, has nothing to do with real science.

In this section I will explore how or if cognitive psychology, as set out in Section 2.3, clashes with the theories of Carnap, Popper, Lakatos, Laudan and Hacking as set out in Section 2.2. I will try to show that cognitive psychology can be a worthy opponent in issues of philosophy of science.

Carnap

Fodor's cognitive psychology is maybe closest to the logical positivism of Carnap, but at the same time totally different. Fodor's internal basic representational system shares many of its logical properties with Carnap's ideal formal language, with the main difference that the latter is an artificial logical language and the former is supposed to be a phenomenon that can be empirically investigated.

The justification of the propositions of scientific theories by confirmation seems to resemble the non-demonstrative learning process of concepts in Fodor's representational framework. Computational steps and their results in a cognitive process do not need a metaphysics for their explanation, just as the logical implications of scientific theories in Carnap's doctrine do not need such an explanation. And if, in an internal representational system, concepts are learned by hypothesis formation and confirmation, then the justification of them is induction, which was enough for the logical positivists.

Another important difference is that logical positivism did not take into account actual scientific practice. It is indifferent to any explanations of the behavior and practice of scientists; these were, in that time, governed by behaviorism. Thus one is led to the biggest difference: the terms in Carnap's language had to be purely observational, while the terms of the language of thought are theoretical. They provide an explanation for certain observable cognitive phenomena: language and intelligent behavior. But if Fodor's thesis about cognitive psychology is assumed then a form of logical positivism could be compatible with it, because an internal basic representational system implies the possibility of an ideal formal language that can provide certainty within it.

Popper

Being compatible with a part of logical positivism does not, for cognitive psychology, imply being totally incompatible with the critical rationalism of Popper. The realization that induction does not guarantee absolute certainty is a logical truth that can be justified in the frame of cognitive psychology.

To start with, there is a difference between the learning of a natural language and the justification of scientific hypotheses within a language. Concepts are a kind of theories about what to expect about instances of that concept. But concepts in natural language are not learned that strictly. Natural language is full of 'falsified' concepts that are entertained anyway. For example, a penguin is a falsification of the concept bird in English, because you expect a bird to fly. But doing science is another process: it can be seen as striving to justified knowledge within the conceptual frame of a language.

Again, first you need a language to state your hypotheses in, before you can test them. Popper argues that one should accept only singular statements, which falsify or corroborate a hypothesis, but this can only be possible within an already known language frame. The goal of developing logically justified hypotheses can only be justified within the logic of a language, and so within the language of thought. Because logic is a characteristic of the language of thought. What can be said of a science is that it develops its own language that tries to be as logically correct as possible, but again, only within a shared mental framework.

The thing that is in conflict with Popper's ideas is that the language of thought introduces the possibility for a true logic of discovery. The operations of justification by corroboration and falsification can be seen as general operations in a process of problem solving. Finding a theory or law that governs the accepted empirical singular statements about a phenomenon can be explained as solving a problem within the frame of a language.

It still leaves room for sudden insights. But because they have to be justified within the terms of the (scientific) language, sudden insights can be seen as suddenly finding a solution within that linguistic frame. In studies of in cognitive psychology it is found out that the process of finding a solution to a problem is not a mere process of trial and error. It can be seen as a heuristically guided search through possible solutions.

Yet, while many scientific discoveries occur within a frame work of a given scientific language, many revolutionary discoveries are accompanied by a change in the conceptual framework of a scientific language. This will only clash with Fodor's thesis if one accepts that every basic term in the language of thought is also a basic term in the frame of a scientific language. However one could argue that one should understand the basic terms, that according to Fodor are needed to explain the whole process of learning a language, are present on a different level of abstraction. In a similar case, the psychologist David Marr argued that we need to assume that the projection of cylinder forms on perceptual data is hard wired in the brain to understand the process of object recognition (Marr, 1982).

Kuhn

One can summarize Kuhn's view of science and his reaction to Popper by stating that there can be no logic but only psychology of discovery. But it is incorrect to conclude that therefore science is not rational or can not be understood as a rational enterprise. With Fodor's thesis about cognitive psychology one can provide an explanation of rationality in science.

Entertaining the concept of the language of thought implies a common logical basis for all possible paradigms of science because theory development and justification is done by human beings who share a common basic conceptual system. Thus, supported by empirical data of cognitive psychology, the acceptance of the language of thought makes incommensurability and the implied relativism unjustified concepts.

Kuhn is still right in rejecting an early form of falsificationism for explaining science, but wrong in rejecting the possibility of a justified form of rationality by just asserting that it is a matter of psychology, because then he clearly underestimates the reach of cognitive psychology. It explains the behavior of individuals as well as their behavior in the context of a paradigm without resorting to social forces only. Of course, it still remains a point of discussion whether it provides a proper explanation.

Lakatos

As an heir of Popper, Lakatos shares his objections against psychology, but again, also without recognizing that rationality can be justified within cognitive psychology. So his refinement of Popper's falsificationism, by allowing an irrefutable theoretical core and letting auxiliary hypotheses take all the refuting blows, can be comprehended in a cognitive psychological frame just as well.

What is incompatible with this frame, is that Lakatos' refinement might allow changing protecting hypotheses forever. But, if the core assumption of a research program is incorrect in respect to the world and the language of thought, changing auxiliary hypotheses would eventually turn out to be empirically unjustified or would otherwise lead to a change in the relation between the language of thought and the scientific language in which the theory is put.

The correctness of a theoretical core can result in unmasking presupposed hypotheses. But if protecting hypotheses would be continuously changed to save the core then all hypotheses eventually lose their meaning (and thus the possibility of comprehension within the language they are put in is lost as well), because they lose their initial relation with the language of thought. Without that relation the theory would not make any sense for anyone knowing the initial scientific language.

Laudan

As for the comparison with Laudan's ideas, cognitive psychology incorporates an explanation of the notion and usefulness of problem solving in science. It entertains these as a basic feature of human cognition that can be rationally guided.

An explanation of why one theory solves some problems better than another can be that, given a scientific language, the one is more truth-like than the other: it is a better possible solution than the other within the space of all possible solutions, within a learned instantiation of the representational frame of the language of thought.

So, successes or progression with problem solving can be explained by presupposing a cognitive process that is, for having success, governed by truth in a representational system.

Hacking

When we see Hacking as accepting only parts of theories, their theoretical terms when they can be manipulated during experiments, we see that this is again a point of view that can be incorporated in a psychological frame, as all other philosophies reviewed so far. One just has to regard the possibility of intervention as a form of rational justification of the reference of terms within a language. From there to, how language relates to the language of thought, it is the same story as above.

Summary

I put forward Table 2.1 as a synopsis of the stances regarding issues in the philosophy of science with Fodor as a participant. I regard the different philosophers as having a philosophical and/or empirical theory about science consisting of: a theory about the scientific practice or behavior of scientists; a theory about what theories represent; a theory about when and how theories develop; and finally a theory why scientific theories are justified or accepted.

	Practice	Representation	Development	Justification
Carnap	-	Empiricism	Confirmation	Induction
Popper	-	Realism	Corroboration	No falsification
Kuhn	Paradigms	Relativism	Normal/revolution	Puzzle solving
Lakatos	Research program	Realism	Progression	Empirical content
Laudan	Research tradition	Pragmatism	Progression	Problem solving
Hacking	-	Entity realism	-	Intervention
Fodor	Prop. attitudes	Internal realism	Confirmation	Problem solving

Table 2.1: Different views on science

Carnap and Popper did not consider scientific practice because they mainly pursued a normative philosophy of science. Kuhn introduced paradigms into the picture and showed how the ideas and behavior of scientists depends sociologically on the scientific paradigm they work in and on. Lakatos adjusted Kuhn's paradigms and explicated the organization of scientists around the theoretical core of a research program. What a scientist accepts depends on the program he is working in. Laudan further extended research programs to research traditions and included, among other things, the conceptual world view of scientists that also determined their adherence and work in a certain tradition. Hacking speaks about scientific practice but he does not pretend to explain it. If we regard Fodor then we should not look only at a sociological level: we can also explain the behavior of the individual scientists on a psychological level, in terms of their propositional attitudes.

What scientists do, should do, or can do is dependent on what their theories represent. Carnap and Popper both thought that theories represent the world with the main difference that Carnap's logical positivism, also called empirism, only allowed theories that represented, or could be redescribed to represent, things that can be observed. Popper's realism had less problems with theories representing unobservables. The relativism of Kuhn on the other hand does not regard theoretical terms or even observational terms as representing anything in the world, because when a theory is developed further the meaning of its terms change as well. Lakatos is as much a realist as Popper was. Laudan, on the other hand, regards theories as useful but does not allow representation. Hacking does allow the reality of 'theoretical' entities if it can be shown that they cause something in experiments. Concerning representation, Fodor allows a realism that is justified with the internal representational system of the language of thought. The terms of theories represent the world in respect to human perception, the language of thought and the particular language a scientist employs. The language of thought thesis incorporates the idea that perception is theory laden, it deals with underdetermination and undermines incommensurability.

A further important philosophical problem is the question when, how and if science develops. According to Carnap we have learned something about the world if a new hypothesis is confirmed. Popper speaks of the corroboration of hypothesis which stood up to critical tests. In both views progression is the result. But when Kuhn looked at history he only saw normal science and revolutionary leaps between incommensurable paradigms in the development of science. Lakatos, however, explicated that when a research program develops the empirical content of the theories should increase. For Laudan there is just progression when a tradition does not run into unsolvable problems. As far as I know, Hacking did not propose his own theory about how science develops. For Fodor, a person learns truths about the world, as well as a natural language, when hypotheses are confirmed in his internal representational system.

The last philosophical problem taken into account concerns the justification of scientific theories. Carnap justifies confirmed hypotheses by induction. But Popper is only willing to pursue a theory when it is not falsified. For Kuhn a theory is still worthy if puzzles can be solved with it during a period of normal science. Lakatos admits theories as long as the research program keeps on increasing its empirical content and does not degenerate. For Laudan problem solving is the goal of science, not truth. Hacking justifies the acceptance of theoretical entities when we can explain

the result of our intervention with nature in terms of them. And finally, Fodor's cognitive psychology admits the acceptance of theories partly by induction but mostly by problem solving. The descriptive and explanatory nature of the language of thought does however allow a normative bent: human problem solving can be analyzed and improved.

This section tried to show that issues and research problems of cognitive psychology can be considered as part of the problems and issues of the philosophy of science. The ideas about the issues clash, but in the same way as the theories within philosophy of science clash with each other. In the next section I will regard how philosophy of science can fall within the frame of cognitive psychology instead of the other way around.

2.5 Integration

Up till now, I argued for a place for cognitive psychology within the philosophy of science. But you can also look at issues of philosophy of science as constituting a part of the issues of cognitive psychology.

As we saw in Section 2.3, Fodor's cognitive psychology is concerned with the explanation of intentional behavior and cognitive processes that result into language and rationality. This is accompanied by an explanation of understanding and comprehension of symbols and the world. Consequently, within the frame of cognitive psychology, scientific theories, as all other symbols, should be processed by a person's mind to have any meaning. Their reference is determined by the person's representational system. That makes truth a feature of the cognitive processes of the mind. Hence, cognitive psychology can in fact be seen as a scientific epistemology.

Theories in the philosophy of science, in that way, can be interpreted as theories about cognitive processes within a representational system that can be empirically investigated within the frame of cognitive psychology. The study of the relations between theories on different levels of explanation would be a study of the processes of thought within the mind and of the mind's representational system. In this way, epistemology can be seen as a science about how human beings know the world, and can learn to know it better. The foundation of knowledge would not lie exclusively in perception of the world, neither would it lie in language, it would lie in how human beings can know about and act in the world on the basis of their representational system: it would lie in the language of thought.

The framework of cognitive psychology is even richer than its capability to explain theory justification, it can explain theory discovery as well. It gives the possibility to study justification and discovery within the same framework. One way of doing so is understanding discovery as the result of an heuristically guided search through a space of possible solutions of a given problem. That problem could, for instance, be: what formulas explain the given empirical data. Investigating the process of discovery would then be investigating how scientists learn heuristics that can find solutions for a problem in a given representational system. In that way it can be seen that justification is also an operation in the process of search on the level of discovery and not just a judgement after discovery.

It is not the case that cognitive psychology does not allow “the spark of brilliance” or any other notion that is related with serendipitous discovery and creativity. There can be more ways of finding a solution in a space of possible solutions than only through a methodological search that is heuristically guided. But the hypothesis of the language of thought implies that: if a solution to a problem can be found serendipitously in a given finite problem space then it can also be found by method.

Finally, the program of cognitive psychology was originally set up to explain individual behavior of human beings, so it may allow us to give an adequate reconstruction of the behavior and ideas of scientists. It is very likely to meet the challenge to justify historical and social data, regardless whether the goal of a scientist is power or truth.

Fodor’s thesis in cognitive psychology provides a theoretical frame for processes of cognition that can explain features of language, thought, and behavior. Those processes are seen as computations in an internal basic representational system. From this viewpoint, theory discovery, development, and justification next as well as intentional behavior of scientists are all governed by computational processes in a representational system which can be empirically investigated. So, cognitive psychology implies a stance within the philosophy of science because the assumptions of the philosophy of science are a part of the assumptions of cognitive psychology.

Hence, we can consider issues of the philosophy of science as part of the issues and research problems of cognitive psychology. Theories of science can be interpreted as theories about certain cognitive processes and their desired results. In the next section I will close this chapter with a general conclusion.

2.6 Conclusion

Should someone accept the theories of a science because he accepts the ideas of a philosophy of science that justify that science? Or should one accept a philosophy of science because it is justified by the science that is accepted?

I tried to make clear in this chapter that, if you accept some idea in the philosophy of science, you implicitly accept some psychology or philosophy of mind, and if you accept some psychology or philosophy of mind you also accept some philosophy of science. They are both about human knowledge and reasoning. If you state how a theory can be justified, you presuppose how a human being can represent theories as well as where they are about. If you state how human beings can have knowledge, and how it influences their behavior, you presuppose how human beings can justify their knowledge. For making this claim, I used the assumptions about cognitive psychology by Fodor and related them to issues in the philosophies of Carnap, Popper, Kuhn, Lakatos, Laudan and Hacking, showing that Fodor and these philosophers of science share a number of issues and assumptions.

What is important for this claim is that it does not matter whether you accept Fodor’s cognitive psychology or not, it holds for every scientific theory about language, thought, behavior, and the brain. If you do not accept a non-physical theory of psychology, but only consider neuro(physio)logical information processing, you still presuppose some account of justification of theories. But if you regard the processes of the mind and brain as computational then you should see a scientific theory as a

computational recipe in a representational system, *i.e.* as a kind of computer program. Looking to theories from that perspective opens up a whole world of new ways to study and understand science with the aid of theories about representation, computation, learning, rationality and behavior within cognitive science.

As a conclusion, I will repeat the claim I argued for in this chapter: cognitive science in general can make sensible contributions to debates, ideas and developments in the philosophy of science because accepting a theory about science is accepting a theory about the mind/brain and vice versa, philosophically as well as scientifically. How psychology can contribute to the debate about the rationality of science is a main topic of the rest of this thesis.

Postlude

Philosophy of Science realized what his young nephew Cognitive Science had in stock. Now they both had to convince their own families about their combined potential. The best way to achieve that was getting to work together and let it be shown...

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