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Kuhn's *Structure of Scientific Revolutions* between sociology and epistemology

Ladislav Kvasz

Institute of Philosophy, Academy of Sciences of Czech Republic, Jilska 1, 11 000 Prague, Czech Republic
Department of Mathematics, Pedagogical Faculty of Charles University, M. D. Rettigove 4, 116 39 Prague, Czech Republic

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ABSTRACT

The aim of the paper is to clarify Kuhn's theory of scientific revolutions. We propose to discriminate between a *scientific revolution*, which is a sociological event of a change of attitude of the scientific community with respect to a particular theory, and an *epistemic rupture*, which is a linguistic fact consisting of a discontinuity in the linguistic framework in which this theory is formulated. We propose a *classification of epistemic ruptures* into four types. In the paper, each of these types of epistemic ruptures is illustrated by examples from physics. The classification of epistemic ruptures can be used as a basis for a classification of scientific revolutions and thus for a refinement of our view of the progress of science.

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Thomas S. Kuhn's *The Structure of Scientific Revolutions* (Kuhn, 1962) was undoubtedly one of the most influential interpretations of the evolution of science in the 20th century. The book sold a large number of copies and provoked an enormous scientific response. It was, to a great degree, responsible for the decline of the neopositivist theory of the cumulative growth of scientific knowledge. The aim that the author posed in the introduction, "to outline a completely different conception of science that may emerge from the historical record of its own scientific investigation" was undoubtedly met. Kuhn's theory was one of the decisive stimuli leading to a radical change of the historiography of science and it became a standard topic in courses on philosophy of science. Nevertheless, 50 years after the publication of the book the time has come for a refinement of some aspects of Kuhn's theory. Where he outlined a global image common to all scientific revolutions, we can present a typology of revolutions. Where he gave a universal scenario, we can offer a whole range of alternative scenarios, each valid for a particular type of 'revolution.'

The question may emerge: Why is it necessary to refine Kuhn's theory? The accuracy of its argumentation was sufficient to show the inadequacy of the theory of the cumulative growth of science. Therefore, an attempt to refine his theory may raise the suspicion of an academic self-indulgence; but this is not so. On the one hand, a common criticism of Kuhn's theory is its non-specificity and ambiguity. Critics have counted in *The Structure of Scientific Revolutions*, 21 different meanings of the term *paradigm* (Masterman, 1970). Partially as a reaction to this criticism Kuhn replaced the notion of *paradigm* by the notion of *disciplinary matrix* (Kuhn, 1974). Thus, the need for clarification of Kuhn's theory was felt by several philosophers of science, and it was admitted by Kuhn himself (Kuhn, 1977, p. xix). The introduction of the notion of disciplinary matrix, however, does not solve the problem. Although it allows an explanation of the concept of paradigm more precisely, in this way only the implicit ambiguity and non-specificity become explicitly articulated. The notion of disciplinary matrix is by no means more precise and specific than the original concept of paradigms was.

I believe that the ambiguity and non-specificity of the concept of paradigm is caused not by the fact that this concept is insufficiently explicated, but rather that Kuhn's notion of scientific

E-mail address: ladislavkvasz@gmail.com

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revolution includes a several processes of a different nature.[1] This does not change by the introduction of the notion of disciplinary matrix. It seems that only when we split the notion of scientific revolution into several types, then will it be possible to specify for each type its own kind of paradigm, and in this way the non-specificity and ambiguity of Kuhn's concept will be removed. Kuhn's concept of paradigm is ambiguous for the simple reason that it is a mixture of several different concepts. It seems that we can distinguish four types of scientific revolutions, which will be discussed in the third section of this paper. They correspond to four kinds of paradigms. Kuhn's 21 meanings of the term are thus split into four groups, each containing approximately six, which can be interpreted as aspects of a single concept.

This refinement of the description of the evolution of science can help one to find one's bearings in debates in the philosophy of science. Many of these debates, such as for instance the discussion between Kuhn and Lakatos, contained an ambiguity because the participants in the debate based their arguments on examples of changes (or revolutions) of a different type. However, since the concept of *scientific revolution* was not internally differentiated, Kuhn and Lakatos formulated their views about the growth of scientific knowledge in universal terms. In this way, they transferred local patterns valid for a certain type of change into universal principles describing the development of science in general; from this, several misunderstandings originated. The controversies about incommensurability can be seen as examples of this type of misunderstanding.

Kuhn's theory can be likened to a picture that arises from mixing four photographs of different faces. Each of the four photographs is sharp and rich in specific detail, but by their superimposing, however, the details will be lost, and what will remain is the gross structure of the face—the overall contours, dark spots instead of eyes and a blot instead of the mouth. Similarly, when Kuhn superimposed the "photographs" of the four types of scientific revolutions, he lost the details of *cognitive dynamics*, that are specific for each type, and what remained in the final picture are only features common to all four types of revolutions—the *social dynamics* of the response of the scientific community to change.[2] The notions of an *anomaly*, a *crisis* or a *revolution* are not specific to science. They can equally be used to describe a group's wandering in the woods. From some observations (*anomalies*) the group can come to the conclusion that it went astray; for some time several suggestions are discussed, which way to take, without any consensus (*crisis*); at the end one of the suggestions is accepted (*revolution*); and the group walks in the accepted way (*new period of normal "wandering"*). The sociological character of Kuhn's theory seems to be a consequence of the superimposing of different types of revolutions. The superimposing "cancels" the *cognitive dynamics*, which is different in every type, and "strengthens" the *social dynamics*, which is always the same.

1. Kuhn's theory in light of the history of mathematics

New impetus for the development of a particular theory often appears when the conceptual framework of the theory is applied to an area for which it was originally not intended. In the new area the concepts of the theory undergo shifts of meaning which open new prospects for the development of the theory. In the case of Kuhn's theory of scientific revolutions, this occurred when historians tried to use Kuhn's conceptual framework to describe the development of mathematics. When Kuhn was formulating his theory, he did not consider mathematics, and so the question of whether the theory of scientific revolutions can be applied in the history of mathematics sparked a vivid debate among historians of mathematics.

At the workshop on the Evolution of Modern Mathematics held in Boston, Crowe formulated the thesis that, "revolutions never occur in mathematics," (Crowe, 1975, p. 19). Some months later, at the meeting of the Society for History of Science in Norwalk, Dauben expressed the view that, "revolutions can and do occur in the history of mathematics, and the Greeks' discovery of incommensurable magnitudes and Georg Cantor's creation of transfinite set theory are especially appropriate examples of such revolutionary transformations," (Dauben, 1984, p. 50). A compromise view between these positions is that of Mehrtens, according to whom some concepts of Kuhn (scientific community, normal science, anomaly), have an explanatory value and offer a tool for the historical study of mathematics, while others (revolution, crisis, incommensurability) are in mathematics without an explanatory value and direct the debate to non-productive disputes, (Mehrtens, 1976). The debate was summarized in the anthology *Revolutions in Mathematics* (Gillies, 1992a).

In the introductory essay to the anthology the editor Donald Gillies sees the source of the disagreements between Crowe and Dauben in different understanding of the concept of scientific revolution. Crowe understands revolution narrowly, as changes during which, "some previously existing entity (be it king, constitution, or theory) is overthrown and irrevocably discarded," (Crowe, 1975, p. 19). In contrast, Dauben understands revolution in a wider sense, as changes during which a particular entity need not be irrevocably discarded, but is, "relegated to a significantly lesser position," (Dauben, 1984, p. 52). According to Gillies both interpretations are justified because there are different kinds of revolution. The different kinds of scientific revolution can be illustrated by examples discussed by Kuhn himself. The *Newtonian Revolution* is an example of revolution of the first kind, because in its course Aristotelian physics was overthrow and irrevocably discarded from the professional training of scientists—if a student of physics today is confronted with Aristotelian physics at all, it is only during the history of science courses. On the other hand, the *Einsteinian Revolution* is, according to Gillies, a revolution of the second kind because in its course Newtonian physics was not irrevocably discarded. Students are still learning Newtonian physics and it is still used in a variety of cases. It was only relegated from the position of *the* fundamental theory of the universe to *a* significantly lesser position of a useful first approximation.

It is important to realize that the difference between the total overthrow of Aristotelian physics during the *Newtonian Revolution* and the relegation of Newtonian physics during the *Einsteinian revolution*, concerns the behavior of the scientific community, and thus it is a sociological fact that every proponent of Kuhn's

[1] Kuhn speaks of large and small revolutions (Kuhn, 1977, p XVII). This may have led McMullin to distinguish between *shallow revolutions* (the discovery of Roentgen radiation), *intermediate revolutions* (the replacement of the phlogiston theory of combustion by the oxidation theory) and *deep revolutions* (the Newtonian revolution) in (McMullin, 1993, pp. 59–61). Kuhn did not accept this distinction: "There are only two points in his [i.e., McMullin's] presentation of my work, from which I have wanted to distance myself. The first is the distinction between deep and shallow revolutions: even though revolutions may differ in size, the epistemological problems they bring are identical for me," (Kuhn 1993, p. 337). The aim of the present paper is to show that there are indeed different types of scientific revolutions, which generate *different epistemological problems*. If we want to justify this, it is not enough to discriminate revolutions of different magnitude, as McMullin did, but it is necessary to offer an epistemological analysis for each of them. The differences between different kinds of revolutions are not only differences in size, but differences of epistemological structure. Each type of revolution alters in the linguistic framework something completely different, and these qualitative differences are reflected in the differences of magnitude of the changes.

[2] Using the metaphor of mixing or superimposing of four different photographs I do not want to say that Kuhn had four different notions in mind, which he intentionally mixed or superimposed. I believe that the mixing was caused by Kuhn's being unaware of (or perhaps not paying attention to) the difference between the different (kinds of) revolutions. The aim of the metaphor is not to criticize Kuhn, but to draw our attention to the fact, that Kuhn's stress of the sociological aspects of scientific revolutions may be the result of such a mixing.

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