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Roy Bhaskar and Ian Hacking
The Problem of Scientific Realism in the Light of Philosophical Reflection on the Laboratory

The position of classical scientific realism gave rise to a wave of fervent debates in the 20th century.[1] The opposition to realism spawned a number of varieties of antirealism,[2] one of them being instrumentalism. The dispute between realists and instrumentalists has its roots primarily in the cognitive status of scientific knowledge or, more precisely, the cognitive status of theoretical objects, such as electrons or positrons. Realists maintain that these objects exist in the way described by their corresponding scientific theories, which can be evaluated in terms of being either true or false. Instrumentalists, on the other hand, claim that scientific theories as such cannot be deemed true or false. Instead, they should be conceived of as tools, or instruments, that make it possible to formulate predictions with respect to the occurrence of specific phenomena which are accounted for by means of observational terms. Instrumentalism can be essentially divided into two variants — partial and holistic. The position of partial instrumentalism was expounded in a systematic and thorough fashion by Rudolf Carnap (1956: 38-76), while holistic instrumentalism was developed and advanced by Willard V. O. Quine (1951: 20-43).

Instrumentalism is not the only challenge faced by realism. Since the dispute between realism and antirealism is quite complex, contemporary methodology and philosophy of science distinguish three distinct planes — metaphysical, epistemological, and semantic — on which the problem can be addressed (Horwich 1982: 181-202, Woleński 1993: 285-286, Szubka 2001: 21-91).

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[1] The position exists in several different versions. One of them, the most commonly invoked, asserts that science discloses truths about reality which exists independently of the cognizing individual.

[2] In subsequent sections, both "realism" and "antirealism" shall refer to scientific (anti)realism.

Metaphysical realism assumes that at least some objects exist independently of any acts of consciousness of the cognizing entity (i.e. “in real terms”).[3] Accordingly, metaphysical antirealism recognizes that the existence of objects is inextricably correlated with acts of consciousness. Epistemological realism, in turn, states that what we cognize (i.e. objects of cognition) is independent of any acts of cognition (is “real”), whereas epistemological antirealism argues that the object of cognition is linked to the cognitive activity of the cognizing entity. Finally, semantic realism assumes full definability of meaning of declarative sentences in terms of transcendent (i.e. real) truth conditions, while semantic antirealism rejects this possibility and proposes that their meaning be reduced to usage conditions, i.e. conditions of their correct assertability.

According to some philosophers of science, the realism–antirealism dispute should not be considered separately on the metaphysical, epistemological, and semantic planes. Jan Woleński, for instance, believes that the differentiation between the first two planes is not justified. His argument is based on ideas put forward by Kazimierz Ajdukiewicz in the discussion of issues related to the boundaries of cognition (Ajdukiewicz 1983: 76-78), where he drew a distinction between two ways of accounting for transcendent objects. Woleński claims that realism is a doctrine within the domain of epistemology. Metaphysical problems introduce “considerable confusion” into realism. They are too nuanced to be considered. For example, if one asks how objects of cognition exist, it is:

> perfectly obvious that further analysis must, first and foremost, establish whether one deals with one or multiple ways of existence, and if the latter is true, whether they are equivalent or perhaps one (or more) can be analyzed in “real” terms (Woleński 1993: 288).

The dispute between realists and antirealists expanded and deepened considerably in the 1980s. Changes are related to a new, untraditional analysis of the method of practising science. The novelty is that the starting point for scientific research practice is thought to be the experiment, not the theory. The experiment is no longer viewed in the “classical” fashion, i.e. as a procedure performed solely to corroborate or refute a particular theory, or to determine a specific detail for the purpose of expanding an existing theory. Experiments are staged in order to reveal how nature will behave under previously untested conditions. The aim of experimentation, as Francis Bacon posited, is to “twist the lion’s tail”, i.e. force nature to disclose its properties in circumstances that could never arise without active human intervention.

The recognition that the fundamental structural unit of science is the experiment rather than the theory has a major impact on the perception of the dispute revolving

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[3] The position of metaphysical realism is sometimes attributed with a radically different meaning from the one addressed in the present study. The other meaning is characterized by Hilary Putnam “as a bundle of intimately associated philosophical ideas about truth: the idea that truth is a matter of Correspondence and that it exhibits Independence (of what humans do or could find out), Bivalence, and Uniqueness (there cannot be more than one complete and true description of Reality)” (Putnam 1988: 107).

around realism. If one addresses the problem of the cognitive status of a scientific theory, the discussion moves towards the realm of epistemology and semantics.[4] By contrast, if the discussion veers towards the experiment, the central issue becomes the existence of theoretical objects that occupy a crucial place in experimental practice as well as the cognitive status of conceptual tools that enable experimentation (Zeidler 2011: 91).

Experimental research practice takes place in the laboratory. This article seeks to outline the problem of realism in the light of philosophical reflection on the laboratory. To this end, two philosophical positions are discussed below: transcendental realism developed by Roy Bhaskar and experimental realism advanced by Ian Hacking.[5] An attempt is made to demonstrate that although both positions embrace the doctrine of realism, its characteristics are so diverse that they give rise to two essentially different concepts of laboratory sciences.

1. ROY BHASKAR'S TRANSCENDENTAL REALISM

Critical realism is a philosophical approach that emerged in the 1970s. It is characterized by four basic tenets: (1) science is possible because it pertains to something that exists independently of researchers and their investigations of it; (2) an important aspect of science is reflection on conditions that must be satisfied by the language used by researchers so as to represent something external to it; (3) science regards external (observable) manifestations of investigated objects as empirical data that may be potentially misleading and fail to expose the essence of things; (4) products of science are always amenable to critique and correction in line with the progress of scientific inquiry.

Thus critical realism, similarly to Charles S. Peirce's pragmatism, declares itself in favour of fallibilism. In this manner, it is very clearly distinguished from two opposite frameworks — on the one hand, from idealist and relativist theories of knowledge which protect themselves from the possibility of being disproved by rejecting the idea of cognizable independent reality, and on the other, from empirical realism which considers experimental data as final evidence for scientific theories (Benton, Craib 2001: 120-121).

The most systematically comprehensive and highly influential version of critical realism has been proposed by Roy Bhaskar. Admittedly, his reflection on natural sciences in *A Realist Theory of Science* is deeply embedded in the theoretistic tradition,

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[4] An in-depth investigation of metaphysical, epistemological, and semantic scientific realism viewed from the perspective of practising science in which the central role is occupied by the theory is offered by André Kukla (1998: 8-11).

[5] Naturally, the two approaches do not exhaust the list of possible accounts of the realism-oriented debate which have been proposed within philosophical reflection on the laboratory (e.g. Giere 1988: 110-140, Zeidler 2003: 105-138, 2011: 41-52, Bińczyk 2012: 51-112).

but it also places a strong emphasis on the concept of the laboratory. The laboratory is ascribed a key role in scientific research practice.

Bhaskar defines sciences as an ongoing social activity which is in a constant process of transformation. Science is produced by the work of man and, therefore, it depends on man. It is subject to changes. Even though Bhaskar sees science as a product of man, crucially depending on the process within which it is produced, he argues that it refers to things existing independently of man. The specific gravity of mercury, the process of electrolysis or the mechanism of light propagation can be given as examples of "objects of knowledge". Science investigates them, but has no contribution to their production. Science is thus a type of social practice which attempts to create knowledge of objects, relationships, processes, etc. that exist and operate quite independently of our knowledge of them (Bhaskar 2008: 52).

Bhaskar formulates his position as a polemic against classical empiricism and Kantism. While both these doctrines revolve around epistemology, critical realism leans mainly towards ontology. *A Realistic Theory of Science* stratifies the domain of reality into three levels. The first level comprises that which is *real*, the second encompasses everything that is *actual*, while the third refers to that which is *empirical*.[6] At the level of the real, generative mechanisms of nature are at work, generating patterns of events for the level of the actual. The former, however, exist independently of the latter. In epistemic terms, they are often "out of phase" with one another. By the same token, observable experiences occurring at the level of the empirical are out of phase with patterns of events (Bhaskar 2008: 47).

Foundations for the formulation of causal laws which are the domain of study of natural sciences are only provided by generative mechanisms of nature. The mechanisms are, Bhaskar claims, just the ways things act:

> Tendencies may be regarded as powers or liabilities of a thing which may be exercised without being manifest in any particular outcome. The kind of conditional we are concerned with here may be characterised as normic [*sic*]. They are not counter-factual but transfactual statements. Nomic universals, properly understood, are transfactual or normic [*sic*] statements with factual instances in the laboratory (and perhaps a few other effectively closed contexts) that constitute their empirical grounds; they need not, and in general will not, be reflected in an invariant pattern or regularly recurring sequence of events (Bhaskar 2008: 3).

Thus laws are not statements pertaining to events or experiences. Their task is to describe structures existing independently of any human activity, with no events that might become objects of human experience. In order to justify the existence of human-independent generative mechanisms of nature at the level of the real, Bhaskar appeals to transcendental argumentation. In answering the question of what the

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[6] Bhaskar naturally assumes that each of the three levels is real in the sense that it remains independent of human intervention. By directly referring reality only to the first level, he stresses that his position represents deep realism, i.e. realism reaching beyond observable events accessible to experience.

world must be like in order for science to be possible, the author turns to ontology. It is within this sphere that he accommodates objects of scientific inquiry. These so-called "intransitive objects of knowledge" can be accessed within the artificial environment of the laboratory. It is only in the laboratory, by applying scientific experimentation, Bhaskar claims, that one is able to intervene in the world in such a way as to isolate a specific generative mechanism of nature and investigate it in complete isolation, i.e. through eliminating its links to other mechanisms. Laboratory sciences investigate *closed systems* which are at least partially isolated from the effects produced by external factors. Laboratory studies seek to uncover objective laws that are also valid outside the laboratory setting. Experimental activity in the laboratory is possible because the experimenter generates a certain constant causal link between events — and not because she creates a law of science that forms the basis for that link.

The precondition for the discovery of laws is the existence of mechanisms of nature which are independent of the experimenter. Without adopting this premise, the course of laboratory experiments would be, Bhaskar notes, unintelligible. Mechanisms existing in the world persist and operate in their standard ways also in open systems, i.e. outside the laboratory which functions as a setting for their empirical examination. As a result, researchers gain knowledge required for the practical application of characteristics of intransitive objects which they have discovered. For example, discovering that electric current generates magnetic field constitutes the basis for the construction of a variety of devices that function in line with our expectations. Therefore, due to the fact that laws of science are interpreted as transfactual statements, i.e. statements that describe the activity of generative mechanisms and structures independently of any particular sequence or pattern of events, one can say that there is an ontological basis for the concept of *natural necessity*.

On the other hand, while exploring the problem of "what science must be like to yield knowledge of intransitive objects", Bhaskar (2008: 11) points to transitive objects of knowledge:

> They are the raw materials of science — the artificial objects fashioned into items of knowledge by the science of the day. They include the antecedently established facts and theories, paradigms and models, methods and techniques of inquiry available to a particular scientific school or worker.

For instance, when Darwin proposed the mechanism of natural selection, he adopted a number of components that made the mechanism identifiable. He highlighted processes of natural variation, the theory of domestic selection and Malthus' theory of population. He then used these components to formulate knowledge of a process that had begun millions of years prior to its discovery. Assuming that Darwin's theory is true, its originator "could not […] have produced the process he described, the intransitive object of the knowledge he had produced: the mechanism of natural selection" (Bhaskar 2008: 11-12).

Scientific discoveries, Bhaskar argues, follow a dialectical pattern. The process begins with identification of a certain regularity in the surrounding world. As the next step, suggestions are put forth to explain the regularity. The final step consists in verifying the solution proposed in the explanation. The author calls the position outlined in *A Realist Theory of Science* "transcendental realism". Transcendental realism and transcendental idealism share the assumption that if science is to be able to explain phenomena observed in experience with the aid of objective laws, researchers must build creative models seeking to capture mechanisms underlying empirical observations. The difference between transcendental idealism and realism is that the former considers such models as constructs that are imaginary, i.e. unrelatable to the world of "things in themselves", while the latter regards them as something that may be real. This is the only interpretation of transcendentalism that allows us to preserve the rationality of scientific development and change (Bhaskar 2008: 135-136).

Bhaskar (2008: 45-46) notes that his concept of the laboratory applies exclusively to natural sciences, especially physics and chemistry. Contrary to what many proponents of naturalism may claim, however, it cannot be applied to social sciences.[7] *A Realist Theory of Science* lists a range of limitations associated with naturalism: ontological, relational, and epistemological (Benton, Craib 2001: 133-135). Ontological limitations concern differences assumed to exist between social and natural structures. The essence of the differences is that: (1) social structures only function because of actions carried out by agents, i.e. they remain conditional on specific activities which are undertaken (this is not the case in natural structures); (2) contrary to natural structures, social structures are linked to concepts in the sense that they are created by acting agents that have distinct beliefs which underlie the actions they perform; (3) in contrast to natural structures, social structures are only relatively permanent. The relational limitation of naturalism, however, is associated with the fact that social sciences are at the same time social practices, which means that they represent a part of their own object of study. As a result, social sciences have a blurred distinction between transitive and intransitive objects of knowledge. An epistemological limitation of naturalism is the fact that only natural sciences enable experiments conducted in closed systems with a view to uncovering objective laws of nature. Beyond closed systems, Bhaskar claims, such laws cannot be unravelled because their progression is affected by the operation of other laws. In contrast, social phenomena occur, out of necessity, in an open system, which precludes their experimental closure.

Having rejected naturalism because of its ontological, relational, and epistemological limitations, Bhaskar does not turn to antirealism but formulates his own the-

[7] In analyzing Bhaskar's framework against naturalism today, attention must be paid to the fact that it differs significantly from the version of naturalism advanced by representatives of cognitive neuroscience who say that social sciences can be confined to investigations of the brain (Churchland 2011: 1-11, 118-162).

oretical stance which he labels *critical naturalism*. Within this theoretical framework, he argues that social sciences are possible precisely because there are marked differences between what is social and what is natural. Scientific methods which are characteristic of social sciences are discussed in (Bhaskar 1998: 17 ff.).

2. IAN HACKING'S EXPERIMENTAL REALISM

Ian Hacking has proposed a different concept of realism. His framework is set within the approach referred to as "new experimentalism". The position embraces the view that science is a type of research activity consisting chiefly in the resolution of problems arising in the course of experimentation. Hacking regards experimentation as the key procedure among the host of research procedures adopted by contemporary empirical sciences.[8] New experimentalists claim that by concentrating on theoretical activity traditional philosophy of science has presented a one-sided picture of research activity. Hacking (1983: 146) emphasizes that theories are linked to attempts aimed at producing representations of the world, while experimentation involves intervening in the world.

The goal of experimentation is to find an answer to the question of how nature operates in a previously unstudied situation. Experiments manipulate the components of the world in order to unravel its mysteries. "To experiment is to create, produce, refine, and stabilize phenomena" (Hacking 1983: 230). Experimenters generate phenomena through their ingenuity and construction of a variety of devices. Such phenomena represent "the touchstones of physics, the keys to nature" (Hacking 1991: 247).

In the perennial dispute between realism and antirealism Hacking declares himself in favour of the former. Nevertheless, he makes a key distinction between theory realism and entity realism. The latter is a specific, in a sense "incomplete", variant of realism. It rejects the classical interpretation of truth as inconclusive. On the other hand, it supports the assumption about the existence of certain theoretical objects (processes, states, waves, currents, interactions, fields, etc.). The objects, though unobservable, are postulated by empirical scientific theories and remain an object of keen interest from scientists.[9] They are real in the sense that they are used as tools of experimental practice.

[8] In his discussion of the procedure of experimentation Hacking is primarily concerned with the experimental practice used in the field of physics. Paweł Zeidler (1999: 55, 2000: 17-34) argues that the procedure is even more applicable to chemistry, which mainly deals with the synthesis of new chemical substances.

[9] Referring to Hacking, Anjan Chakravartty (2007: 14-15) divides the category of unobservable objects into detectable and undetectable. The former are those that can only be detected using instruments, while the latter cannot be detected at all because they give rise to no interactions (i.e. they are "causally inefficacious"). One example of objects (processes) that are unobservable yet detectable is the neutrino, an elementary particle arising as a consequence of weak disintegration of other particles such as neutrons. The neutrino was first postulated theoretically by Wolfgang Pauli.

If certain “home truths” are known about selected theoretical objects, e.g. electrons, that is to say, if specific causal properties are established,[10] a device can be designed to systematically control electrons in accordance with our presupposed expectations and aspirations. For example, it is possible to disintegrate an atomic nucleus by bombarding it with a flux of electrons. In this scenario, the electrons cease to be analyzed as something inferred for the purpose of explaining observed phenomena (as in Bhaskar’s transcendental realist framework). Instead, the electrons themselves start creating phenomena. They assume the role of tools of intervention in the world. Therefore they become „instruments not for thinking but for doing” (Hacking 1983: 262).

Processes involved in the creation of new objects and phenomena are studied by laboratory sciences. Such sciences, according to Hacking, seek to design and use special apparatus for intervening in the untainted state of nature (“a pure state before people”) in order to isolate and purify existing and create new phenomena. Such interventions, in turn, result in the drive to effect changes in the world and to gain increasing control over phenomena stemming from these changes (Hacking 1992: 33).[11]

Laboratory research practice comprises an array of factors which enter into a variety of interactions with one another. Such experimental elements are grouped by Hacking into three classes: ideas, things, and marks. Each of the groups comprises five components. The class of ideas contains a host of questions and theories which make up the intellectual content of activities performed in laboratories. The class of things consists both of material substances which are examined or which are used for scientific investigation, and of devices, apparatus, and theoretical objects used in studies. It also comprises experimenters who are involved in research. The class of marks includes outcomes of laboratory experiments together with their interpretations (Hacking 1992: 44-50, Sikora 1996: 101-107).

All the elements of laboratory research practice are closely interrelated, and they condition one another. What is more, they may change their nature in the course of experimentation. Contrary to claims made by some scholars, e.g. Peter Galison (1988:

Thanks to the research undertaken by Frederick Reines and Clyde Cowan most information about the properties of neutrinos was obtained in indirect experiments. Currently, nuclear reactors and high-energy accelerators make it possible to detect neutrinos directly. Examples of undetectable unobservables include Newtonian concepts of position and velocity with respect to absolute space, as well as certain mathematical objects.

[10] Hacking classifies “home truths” as a low-level theoretical structure used by scientists in experimental studies. The characteristics of these truths, however, are imprecise and give rise to a major uncertainty (Rosnik 1994: 395-411).

[11] Hacking excludes paleontology and astrophysics from laboratory sciences, even though both disciplines make use of results obtained in the laboratory setting. Economics, sociology, and psychology are also considered to be outside the realm of laboratory sciences. Sciences which use a primarily observational or classificatory approach to achieve scientific understanding, as well as historical sciences, are completely outside the scope of Hacking’s interest.

525), the above also applies to theoretical assumptions. The elements included in all the three classes of Hacking's taxonomy are so strongly linked to technological components that the traditional division into theoretical and applied aspects of science cannot be upheld. The situation is clearly manifest in the account of phenomenological topical hypotheses used in experiments. The hypotheses are meant to combine general laws of systematic theory with empirical phenomena. The combination is only possible given a set of procedures for modelling and for formulating approximations. Another element playing a major role in combining the theoretical and technological dimensions consists in modelling the research apparatus applied in the laboratory. The process of modelling has two main aspects: the adopted theoretical assumptions are the basis for establishing the operation of the apparatus and for determining its interactions with objects studied by experimenters or serving as study aids.

One of the consequences of the possibility for modification and mutual adjustment of all elements involved in experimental works is the stability of laboratory sciences. As emphasized by Hacking (1991: 29-30), researchers operating within these sciences seek to create a self-vindicating structure which maintains its stability. Hacking describes the thesis about the stability of science as an elaboration of Duhem's doctrine: the original theory only accounts for the fact that science changes people's ideas about the world, without duly recognizing that science also changes the world itself. Duhem's doctrine, developed by Quine, is commonly invoked as a proof for the claim about the underdetermination of scientific knowledge. Hacking (1992: 56), however, advances the view that the doctrine, when developed consistently with its original intentions, has different effects: it reveals that the world and the scientific knowledge of the world mutually determine each other. In advanced laboratory sciences, theoretical premises and research apparatus are mutually self-vindicating in the process of data interpretation. Elements of laboratory practice create a symbiotic relationship between people, scientific organization, and nature. They constitute what Hacking (1996: 65) refers to as the "laboratory science style".

Although experimentation entails that phenomena are created rather than discovered, Hacking (1999: 68-80) defends the thesis that phenomena are indifferent to the observer. In his account of laboratory sciences he consistently disregards factors that are related to the concept of worldview (*Weltanschauung*) of the experimenters. Hacking (1991: 51) is only concerned with the internal elements of experimentation while rejecting all external elements of this activity.[12]

He also notes that laboratory sciences only occupy a certain area of natural sciences and underlines the distinctive difference existing between natural and human sciences. The former make use of classifications that result in what he dubs "indifferent kinds". In the latter, by contrast, classifications give rise to "interactive kinds". Objects explored by natural sciences remain relatively stable, whereas those investigated by

[12] The latter are the central object of interest of researchers specializing in science and technology studies (Knorr-Cetina 1995, Pickering 1995, Latour 2004, Sikora 2012).

human sciences lack stability due to the looping effect. It means that, for example, quarks are not aware of how they are classified. Based on the body of knowledge accumulated about them, quarks can be made to behave the way we want them to in the particle accelerator. Nevertheless, they are still indifferent to our knowledge and do not modify their behaviour in view of what we know about them. They are neutral towards it (Hacking 1999: 100-124). A different situation occurs when the object of study relates to humans, their beliefs and actions. If this is the case, classifications make those who are being classified aware of their classificatory assignment. Classified human objects may then interact with the classification and choose to modify their behaviour *because* of how they were initially categorized, thus effecting a change in the classification.

CONCLUSIONS

Comparing and contrasting Bhaskar's transcendental realism and Hacking's experimental realism shows that the doctrine of scientific realism requires more detailed elucidation today. The above statement becomes especially clear after comparing concepts of laboratory sciences associated with the two types of realism.[13] Hacking's concept of these sciences is radically different from Bhaskar's framework.

The latter author defines the fundamental goal of laboratory sciences as the investigation and detection of generative mechanisms of nature which govern the course of real phenomena. He calls the mechanisms "intransitive objects of knowledge" and postulates that they are only accessible to exploration in an artificial environment created in the laboratory. The laboratory is a setting that allows generation of isolated closed systems in which experimental scientists are able to unravel the objective laws of nature. Such laws are not accessible to discovery in open systems

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[13] An interesting proposal in the dispute about realism in the laboratory practice of science has been put forth by Zeidler, who claims that exploration of the role and function of language used by experimenters during experimental practice for designing, describing, and explaining experiments does not require investigating the objective reference of the adopted concepts. More specifically, it is not imperative to consider whether the objective reference of the concepts enjoys the status of reality. In order to account for the effectiveness of experimental practice, Zeidler explains, it is sufficient to fall back on the procedure of objectivization of concepts employed by experimenters. "Experimenters must objectivize the concepts they use because this is the only way to ensure the effectiveness of *conceptual tools* (e.g. theoretical models) from the viewpoint of their laboratory practice. This objectivization may be — and often is — independent of the interpretation of concepts found in scientific theories, and does not entail the assertion about the »reality« of objective references obtained in this way. What is more, I believe, experimenters may realise (and they often do) that objectivization is a measure leading to the emergence of a postulated reality" (Zeidler 2003: 107). Thus Zeidler does not side with any parties to the dispute on laboratory realism but instead maintains a neutral stance.

because such systems inherently harbour a complex set of mutual interactions. As a result, the pattern of operation of some laws is perturbed by others.

By contrast, Hacking argues that laboratory sciences are not meant to discover objective laws of nature but rather to intervene in the world and use dedicated apparatus to create phenomena which do not appear spontaneously in nature. An important effect yielded by laboratory sciences is the possibility for bringing about changes in nature and for controlling them to an increasing extent. All elements of laboratory research practice are closely intertwined with one another. They form a self-vindicating structure which exhibits a high level of stability and illustrates a considerable degree of interdependence between the world and the possibility of modifying the world by means of laboratory sciences.

Despite fundamental differences between Bhaskar's and Hacking's concepts of laboratory sciences, both authors admit that the notion refers only to the narrow category of natural sciences. They agree that experiments conducted in the laboratory cannot be extrapolated to human sciences. In fact, the latter are not amenable to application of laboratory research practice at all.

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