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Basic Contents and Contributions of Hacking's Experimental Realism

JU Xintong[a],*; YANG Yuhui[a]

[a]School of Political Science and Public Administration, Southwest University, Chongqing China.
*Corresponding author.

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Abstract

Based on the debate between scientific realism and anti-scientific realism and philosophy of science is too theoretical, Hacking put forward experimental realism. Experimental realism illustrates the importance of experiments in science, and put forward its four basic propositions: (a) Experiment is the basis of science. (b) The experiment entity operable. (c) The content of experiment is operating experimental entity. (d) Experiment entity causal attributes the fundamental basis of experimental research. "The experiment has its own life" is a special proposition and its connotation is: (a) Experimental entity is independent of the specific theoretical certainty and stability. (b) The experiment system has its own independent status and structure. (c) Laboratory activity and result are decided by its own true nature. Experimental realism resolved the conflict between scientific realism and anti-scientific realism, broke the theorical tradition, understood the relation between the experiment and theory, and promoted the development of scientific practice philosophy.

Key words: Hacking; Experimental Realism; Basic Content; Experiment; Contribution

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INTRODUCTION

To find out the basis of ontology for science was a basic target of scientific realism in the 20th century. Therefore, some scientific realists make great efforts, and the representative personage of new experimentalism, Ian Hacking makes specific contributions to solve scientific realism with his proposed experimental realism.

1. FUNDAMENTAL REVELATION OF FUNCTIONS OF EXPERIMENTAL REALISM TOWARDS EXPERIMENT IN SCIENCE

From the observation and study of Representing and Intervening and other pertinent literatures of Hacking, we can see one of his greatest theoretical contributions is more definitely elucidate the important role of experiments in science, and just his explanations about the position and role of experiments in science constitute the core content of experimental realism. According to the cognition of Hacking, the functions of experiment in science presents in four aspects: experiment is the realistic foundation of science; experimental entity has operability; operation on experimental entity is the basic content of experiment; the causal property of experimental entity constitutes the prime base of experiment research. A brief discussion about these four aspects will be given as below.

1.1 Experiment Is the Realistic Foundation of Science

In terms of Hacking, to correctly know experiment, people shall free themselves from the tradition of theory dominance. Hacking indicates that

> scientific philosophers always discuss the presentation of theory and realism, but they usually avoid discussion of remolding the world with application of experiment, technology or knowledge.

> This is very strange, because "experimental method" has ever been the pronoun of scientific method. (Hacking, 2010, p.121)

Actually, experiment plays a significant role in the establishment and development of modern science. The rise and development of science will be unavailable if experiments fail to be introduced. The scientific revolution in the 17th century fluctuated the dominant position of scholasticism, and helped people to realize that experiments were the footstone to the way of science. The experimental scientist, Roger Bacon has ever advocated that experiment was the reason of knowing phenomenon, and only experiments could distinguish the effects generated by the nature, human and cheating (Lin, 2004, p.64). Hacking clearly sees that under the intervention of experiments, object and nature will no longer be vague and unordered, but to be expressed to scientists in a clear and regular way. Certain observation and experimental results are the realistic foundation and realistic basis for scientific theory establishment. Those scientific theories divorced from observation statement can only be the superempirical mysterious saying, and those scientific theories without experimental test can only be the hypothesis to be verified. The significances and values of experiments are reflected not only in the meaning of observation proposition as experimental result, but also in the connotation of experiments which include observation proposition, experiential statement and experimental activity as experimental result. Experimental activity is a kind of intervention and remolding towards the natural world, is an item of corporality practical activity of learning the world, and is the realistic foundation of science.

1.2 Experimental Entity Is Provided With Operability

The operability of experimental entity means the nature of observing, affecting and changing it by technological means. Hacking thinks that just the operability of experimental entity shows the realistic character of science. In the argument about scientific realism and anti scientific realism, dispute exists in the reality of two kinds of experimental entities: One is extremely weeny but observable entity; the other one is the entity from hypothesis of theory but cannot be observed, such as particle, field, process, structure, state and so on. With the example of the first entity, scientists will observe the experiments with the scientific instrument, microscope. But, "to be observed" means that they are realistic? Van Fraassen does not think so. He takes the gas wake flow of jet aircraft and electronic ionization track in cloud chamber as an example, and indicates that both are produced in similar physical process, but we can find that plane who erupts gas, but cannot wait electron landing and see electron. Therewith, Hacking thinks that the same structure of entities can be observed through different physical systems of microscopes, so as to confirm the reality of this entity. He states briefly that in the history of science, the electron microscope and fluorescence microscope in different physical structures both find the "punctations" in blood platelet present identical grating arrangement and ordinary cellular structure. Hacking writes, "Two distinctively different physical processes present same visual modality time and again. If they are only the man-made product of physical process rather than the real structure of cell, such coincidence indeed is too absurd." (Hacking, 2010, p.161) In terms of Hacking, displaying and changing experimental entity with the method of technical operation is just the scientific capacity expression. If the object is not provided with operability display and change, it cannot be scientific. Just on a basis of the operability of experimental entity, scientists can conduct experiment research and inspection through the operational means of experiment observation.

1.3 Operation Towards Experimental Entity Is the Basic Content of Experiment

For Hacking, the basic content of experiment is to observe, affect and change experimental entity with technological means, and create phenomenon through the experimental entity operation of causal property. Experiment is the most fundamental expression of scientific realism. For those entities from theoretical assumption but to fail to be observed, their reality shall be proved with the method of experimental operation. Hacking thinks if certain theory can be used as a tool to operate other things of nature, we have reason for believing such entity is real. With electron as an example, he indicates that scientists research and master the properties of electron, and produce tools (such as electronic gun) with electron. Then, electron becomes a kind of operable tool, and is not the entity of assumption and inference any more. It becomes an experimental entity. For the operations of experimental entity constitute the basic content of experiment, Hacking writes,

> experiment research provides strongest and most powerful evidence for scientific realism. This is not because we check the hypothesis about entity, but because those entities that cannot be 'observed' in principle can be regularly operated to create new phenomenon and explore other aspects of nature. They are tools and means, not for thinking, but for some affairs.

Therefore, scientists create phenomenon through theoretical entity operation of other natural things, so as to confirm the reality of this entity. Then, the operations towards this entity constitute the basic content of experiment.

1.4 Cause and Effect Attributes of Experimental Entity Constitute the Fundamental Foundation of Experimental Study

Hacking believed that the fundamental purpose and method of experimental studies were to explore the cause and effect attributes of experimental entities. If the cause and effect attributes of experimental entities can be utilized to make machines that work very reliably,

then this would be the best proof of the realism of the experimental entities. Hacking gave an example of Faraday demonstrating magnetic line of force. The magnetic line of force can be visible when the scrap iron surrounded the magnet. And the magnetic line of force was densely covered at which the scrap iron was thick. Faraday held that these magnetic lines of force can be cut to obtain a real effect (e.g. the electromotor he invented) because they were real (Hacking, 2010, p.30). Proving the realism of magnetic line of force by the thickness of scrap iron, Faraday took the significant step in the history of science in demonstrating the realism of experimental entities by means of cause and effect attributes. Therefore, the experiment is intended to observe and manipulate the cause and effect attributes of the experimental entities, and also create a stable new phenomenon and make a reliable tool as well as a stable machine by using the inherent laws of the entities. It can be seen that the cause and effect attributes of experimental entity constitute the fundamental foundation of experimental study.

2. EXPERIMENT HAS ITS OWN LIFE

In order to define the independent status of experiment in scientific research, Hacking also proposed the proposition that "experiment has its own life". The author believes that the proposition can be interpreted from the following three aspects:

2.1 Experimental Entity Has Definiteness and Stability Independent of Specific Theory

The entity that Hacking discussed was implied in experiment, thus, it was called "experimental entity". Taking the electron as an example, in *The Scientific Image*, Van Fraassen questioned whether the electron that Millikan observed was Lorentz's, Rutherford's, Bohr's or Schrodinger's from the anti-realism standpoint. Hacking quoted Putnam's reference theory to argue in favor of the electron. Putnam has always been opposed to the incommensurability of meaning, believing that extension or reference was both parts of meaning. These elements were not the Frege-type meaning, but the invariable eternity, namely the stable extension of the word. Although the theoretical description of a certain entity may be changed, the theoretical words can always be referred by different theorists and experimentalists as the same entity, which was reflected in the history of science when the electron was found. "The discovery of X-ray, uranium-ray and radioactive element lied in the chain reaction caused by cathode ray. Then what was the cathode ray itself?" Hertz believed it to be the "ether wave" and others thought it to be an electriferous atom. Crooks once believed it to be the fourth state of substance. In 1879, Crooks found out that the cathode ray was an electronegative particle (Lin, 2004, p.238). In fact, those theoretical words, such as cathode ray, ether wave, the fourth state of substance and electronegative particle, refer to the electron called by us today. In spite of the changes in scientific theory, the entities these theoretical words refer to have not been changed. Perhaps different scientists may implement many different experiments on an entity, but as long as we can confirm that the theoretical words they use refer to the same entity, then no matter how the theories and experiment may change, the theoretical words have the common reference.

2.2 Experimental System Has Its Own Independent Status and Structure

Both the empiricism after restoring the experiment to observe proposition, and the post-positivism after classifying it into the field of scientific theory, are defining the experiment from the perspective of epistemology. Hacking's experimental realism looked upon the practice activity itself from the ontological point of view, revealing that the experimental system had its independent status and structure. First of all, the experiment has the status independent of the theory. Hacking pointed out that the relationship between experiment and theory should be diversified.

> Some of the most profound experiments were entirely created by theory. Some great theories came from pre-theoretic experiments. Some theories were dead because they were unmatched with the real world and some became meaningless due to the lack of theoretical support. However, there were also happy combinations that theories and experiments from different direction meet each other. (Hacking, 1983, p.159)

The relationship between experiment and theory is complex, not simply theory predominating experiment or experimental testing theory. The independence of the experiment needs to be recognized. In the field of science, the experiment should have the same importance or even more significant status than that of the theory. Secondly, the experiment has its own independent structure. Hacking has divided the components of experimental activities, indicating that the system has its own independent structure. In the *Self-defense of Laboratory Science*, he divided experimental activities into three categories: the concept (theory), the things (the material part of the experiment) and the marks (the result of the experiment). Among that, the concept included the problem, the background knowledge, the systematic theory, the current hypothesis and the modeling of instrument; the things including objects, modified resources, detectors, tools, and manufacturing data; the marks including data, data evaluation, data summarizing, data analysis and interpretation (Hacking, 1992, pp.29-64). Obviously, Hacking did not confine the experiments to intervention, observation, instrument operation and data acquisition. Instead, he regarded experimental activities as a complete process, including the theory, experimental materials and experimental results. Although such division has caused contradiction from Latour and other philosophers

of science, Hacking's study of experimental system has revealed the independent structure of experimental system and emphasized the independence and importance of the experiments as practical activities.

2.3 Experimental Activities and Results Are Determined By Their Own Nature

Scientific experiments require high degree of stringency, including the rigor of experimental design, the preciseness of the experimentalists' attitude, the normativity of operation process, and etc. There are many factors affecting the experimental activities and results, such as design ideas, experimental equipment, and operation process, but it is the real nature of experimental entities that determines experimental activities and results. Hacking gave an example that Hall Effect found by Hall in 1879. When Hall studied the comments of Maxwell's *Treatise on Electricity and Magnetism*, he speculated that Maxwell was talking about that the conductor resistance could be affected by magnetic fields, or generate an electric potential. Finally, Hall reached a conclusion in the experiment that when current passed through a conductor perpendicular to the external magnetic field, there would be electric potential at the two sides of the conductor parallel to magnetic field and along the direction of current. At that time, some philosophers insisted that the electromagnetic effects that Hall had discovered were only by chance and the experimental activity and result were determined by God. They were just waiting for the scientists to find out. Hacking retorted:

> I hold the contrary opinion. Hall Effect does not exist outside of the specified instrument. We should not have such an image: The god holds the Hall Effect in his left hand and another law in the right hand, and then determines the results. The complicacy exists in nature. It is the complexity that we can apparently analyze. Our analysis not only relies on distinguishing a variety of laws in the mind, but also the pure and isolated phenomenon presented in the laboratory. (Hacking, 2010, p.181)

In brief, the experimental activities are actively established by scientists, and the experimental results are determined by the nature of the entity itself.

3. CONTRIBUTION OF EXPERIMENTAL REALISM

Experimental realism had caused great repercussions in the field of philosophy of science since it was put forward. In spite of its own inherent problems, its contribution was enormous. Its contributions were mainly reflected in the following four aspects:

3.1 The Experimental Realism, to a Certain Extent, Eliminates the Conflicts Between Scientific Realism and Scientific Antirealism

The debate between scientific realism and scientific antirealism mainly lies in the reality of non-observable theoretical objects, and whether the scientific theories should be regarded as the truth in an unlimited sense. The experimental realism Hacking put forward was not the scientific realism in a universal meaning, but based on the realism of experimental entities. He proposed that experimental entities were provided with maneuverability, and made clear that the fundamental purpose and method of experimental studies and the basic were to explore the cause and effect attributes of experimental entities, as well as emphasized that experiments have their own life. The experiment was not an idea or theory, but was intended to intervene with and transform objects with specific tools. The argument Hacking demonstrated from the angle of intervention defended the scientific realism theory to some degree, and also eliminates the conflicts between scientific realism and scientific antirealism to a certain degree.

3.2 Secondly, Experimental Realism Has Broken the Theory-Dominated Tradition in Philosophy of Science Through the Ages

Experiment, from the perspective of traditional philosophy of science, has been deserted, either in the eyes of logical positivism represented by Rudolf Carnap, or Popper's falsificationism, or Kuhn's historicism or new historicism of Laudan, Sharpere et al. Philosophers of science tend to pay more attention to the theory instead of scientific experiments. Kuhn once argued that "in the natural sciences, a large number of qualitative work were usually a prerequisite for the productive quantitative work. However, the effective quantitative comparison between theory and nature came into being in the very late stage of scientific development. At this stage, theory seemed to have such a decisive leading position (Smith, 2006, p.146). The experiment was simply considered as a tool to test the theory, which was dependent on the theory and the pattern. It was not possible to exist in the form independent of theory. If we only talk about the terms of scientific theory and separate scientific practical activities from theories, philosophy of science would lead to misunderstanding of relativism. It is the proposal of experimental realism that helps the scientific philosophers have a new understanding of the nature of the experiment and its important role, so that the theory-dominated tradition in philosophy of science through the ages can be broken.

3.3 Experimental Realism Reassesses the Relationship Between Experiments and Theories

In traditional philosophy of science, there have been two viewpoints about the relationship between theories and experiments. The logical empiricism holds that experiment is to provide propositions about the world, and the experiment is affiliated with the theory; while the post positivism believes the theory ladenness of observation and experiment. Hacking, by the cases of the history of science, proved that experiments were people's intervention with the nature and the practical

activities independent of theories. Hacking introduced the slogan that "experiment had its own life", indicating that experiments were provided with equal or higher status than theories, and that it had the decisive significance for strict experiments to confirm or falsify a theory. That responded to the interrogation brought about by the underdetermination thesis.

3.4 Experimental Realism Plays an Important Role in Promoting the Philosophy of Scientific Practices

The experimental realism not only criticized and transformed the traditional philosophy of science that had the theory priority, but also promoted the development of the philosophy of scientific practices. The new experimentalism was an important part of the philosophy of scientific practices, and a significant school in the development of philosophy of science. Hacking's works were the pioneering ones in new experimentalism. The experimental realism has been a strong impetus to the development and progress of the new experimentalism. The new experimentalism admitted the diversity of experimental and scientific activities, and conducted analytical studies on the experimental activities from perspectives of material concept of experiments, the cause and effect of experiments, the relation between science and technology, theory's role in the experiment, modeling and experiment, the scientific and philosophical significance of the use of Instrument and other aspects. After Hacking, Gooding, Franklin, Gallison, Radbruch and a large number of other scientific philosophers supported the new experimentalism. They played a significant role in promoting the development of practical philosophy.

Of course, the experimental realism, in a special sense, also reflected its own limitations. Therefore, some scholars put forward different views on the experimental realism, considering it as a realism in a special sense. Hacking may be electronic realist, but not necessarily the quark realist. Such a view had rationality to some degree, but this cannot deny the importance of experimental realism. Hacking also pointed out that when reviewing the history of science:

> Now I had to admit some skepticism, such as the doubt of black hole .I suspected that there may be another kind of universal representation, which was also consistent with the phenomenon after the exclusion of a black hole. I inherited the aversion of mysterious forces from Leibniz. Let's recall how he denounced Newton's gravity as a mystery. Two centuries later, he was proved right. Newton's ether was also very mysterious. It taught us a lot. Maxwell studied the electromagnetic waves in the ether, and Hertz proved ether by proving the existence of the radio waves. Michelson found a way to interact with ether. He believed his experiments validated Stokes' theory of the ether drag, but in the end his experiments became one of the many reasons that he gave up the ether ghost. A skeptics like me had a small conclusion. If the long term existence of theoretical entities was unable to control, then the usual result would become a beautiful mistake. (Hacking, 2010, pp.217-218)

Theoretical entities in the scientific field were countless. Scientists needed to confirm or falsify the reality through a lot of experiments, which were a long and arduous process. The emphasis of experimental realism was not to put all of the theoretical entities in the laboratory for test, but to emphasize the realism idea that separated experiments on theories. The reasons and basis of the entities' reality should be on the basis of experiments. Of course, with the development of science and technology progress, the number of entities that can be manipulated by experiments will increase.

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