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Review Article

The Role of Experiments in the Progress of Scientific Theories

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Abstract

Experiments play an important role in the progress of scientific theories. In the coordination theory, Lei Ma proposes the concept of "coordination force" to describe scientific rationality. The experiment is one of the main factors to examine the view of background coordination force. Different experiments play different roles in improving the theoretical coordination force. Based on the coordination theory, through analyzing the role of experiments in scientific progress, we can find that physical experiments mainly play a role by improving the empirical coordination force of scientific theories, while thought experiments mainly improve the coordination force of scientific theories in terms of conception and background, but at the same time, it can also contribute to the improvement of the empirical coordination of theories. Therefore, thought experiments can simultaneously affect the three parts of the theoretical empirical coordination force, conceptual coordination force and background coordination force.

Keywords: Experiment; Theory; Coordination theory; Coordination force; Physical experiment; Thought experiment

Introduction

In the book of "Conflict and Coordination: A new Theory of Scientific Rationality", Lei Ma proposed a novel scientific rationality model of coordination theory. In the coordination theory, Lei Ma proposes the concept of "coordination force" to describe scientific rationality. The coordination force includes three parts: empirical coordination force, conceptual coordination force, and background coordination force. The coordination theory takes the problemor [1] and the solutionor [2] as the basic concepts. It sets up ten In

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[1] The coordination theory holds that any theory is composed of two parts: the question and the answer to the question. A problemor is composed of questions and questioning methods. Problemors are the things that we are curious about, eager to understand and ask questions about.

[2] The answer to the question is composed of the solutionor and the connection of the solutionors. The solutionor is a general term for all single internal and external strategies.

evaluation indexes for the empirical coordination force[3] [3] and eleven evaluation indexes for the conceptual coordination force[4] [4] from the aspects of novelty, rigidity, clarity, consistency, accuracy, harmony, diversity, simplicity, unity, certainty, coherence, and profundity. It sets up five evaluation indexes for the background coordination force[5] [5] from the aspects of experiment, technology, thinking, psychology, and behavior. In this way, the strength of theoretical rationality can be presented by comparing the coordination force between the different scientific theories, thus the direction of science progress can be pointed out for the theories.

The coordination theory holds that the experiment is one of the main factors to examine the view of background coordination force. As a superior means of exploring the world, experiments occupy an irreplaceable position and play an important role in the process of understanding the world. Newton's experiment on the pendulum improved the empirical coordination force of his theory of the relationship between weight and mass. The leaning tower experiment in Pisa improved the conceptual coordination force of Galileo's free fall motion theory. In 1919, Eddington's expedition to observe the bending of light phenomenon improved the empirical coordination force of Einstein's theory of relativity and won Einstein a high reputation. It also laid the scientific status of Einstein and improved the background coordination force of relativity. It can be seen that different experiments play different roles in improving the theoretical coordination force.

Redivision of types of experiments

According to the coordination theory, experiments need to be classified. The traditional experimental classification scheme is a simple division into physical experiments and thought experiments, which represents only two extremes: material-based and thought-based experiments. However, this simplistic dichotomy cannot account for all experiments, as many experiments involve both material and cognitive elements, and thus are a combination of material and cognitive carriers. Different types of experiments play distinct roles in advancing scientific theories.

Because experiments play an important role in solving theoretical problems, according to the classification principles of empirical problems, conceptual problems and background problems, we can start from the carrier of experiments and divide experiments into physical experiments, thought experiments, and mixed experiments including material carriers and thinking carriers.

A physical experiment usually refers to the scientific activity that occurs in the laboratory and takes the objective material existing in the physical form as the carrier. People observe the phenomenon of things changing under the certain conditions to understand the essential law of things. The experiment is different from the observation in daily life, mainly because the conditions for things to change are superior. This superiority is manifested in two aspects: from the external conditions of the phenomenon, the experiment excludes various interference factors and creates an external environment suitable for things to change. For example, to observe the oxidation of metals, people can place the metal in a gas cylinder filled with pure oxygen for observation, in order to facilitate the obvious occurrence of oxidation. From the perspective of the change of things themselves, people can select high-quality materials for the occurrence of phenomena. For example, in the study of biology, to observe the living habits of rabbits, people can choose different rabbits with different varieties, a certain age, a certain weight, different gender, from the perspective of diversification, to select the experimental objects, in order to better show the traits that people want to get. Indeed, physical experiments play an important role in the process of theoretical problem solving. It has accumulated rich empirical data through multiple observations from different sides. It plays a key role in solving empirical problems. Empirical data is called empirical problem or in the coordination theory, which is an important parameter to calculate the theoretical coordination force. Since modern times, physical experiments have received extensive attention in scientific research activities. This is probably due to the brilliant achievements of modern science under the impetus of physical experiments.

In comparison, thought experiments have been in a neglected situation. Just as the name implies, thought experiments are happening in people's minds, with people's thinking as the carrier. In the minds, we imagine an experimental situation, and then we "see" the phenomenon of things changing. Unlike physical experiments, which are conducted in a laboratory, thought experiments are the result of people's thinking and the process occurs in people's minds, the various conditions of the thought experiments are completely idealized. "Smooth frictionless plane", "people who running at the speed of light", "demons that can distinguish the speed of molecular

[3] Empirical coordination force refers to the effectiveness of theories to solve empirical problems. The empirical coordination force not only focuses on whether the theories solve the empirical problems, the number and the weight of the empirical problems but also focuses on other ways and efforts of the theories to solve the empirical problems.

[4] Conceptual coordination force refers to the effectiveness of the theories to solve conceptual problems. The conceptual coordination force focuses on the relationship of conflict and coordination between concepts and viewpoints within the theory, between two theories, and between theories and the broader scientific beliefs.

[5] Background coordination force refers to the effectiveness of the theories in solving background problems. Background coordination force focuses on the source of the theories and the ultimate value of the theories. It plays an irreplaceable role in the theoretical evaluation of the theoretical empirical coordination force and conceptual coordination force

movement", "stones that can infinitely become larger or smaller", and so on. Thought experiments are only the result of working in people's minds, so they do not involve any new empirical data. This essential characteristic determines that thought experiments mainly play a role in the solution of conceptual problems. However, it should be noted that the role of thought experiments is far more than that. they can also provide problem-solving ideas in solving theoretical empirical problems[6] [6], thus having indirect empirical coordination force. Of course, both physical experiments and thought experiments can make their own contributions to the improvement of the background coordination force of the theories.

The third type of experiments is a mixed experiment, which includes both material carrier and thinking carrier. The existence of such experiments is because the method of simple material or simple thinking is not fully applicable in many cases. Because there are many experimental carriers that cannot be simply defined as material or thinking. To be precise, the carrier of some experiments should be a combination of material and thinking. The mixed experiment provides the question of calculating theoretical empirical coordination force and conceptual coordination force, and plays an important role in evaluating theoretical progress.

So far, people's description of the world is still based on three partial theories, namely Newton's classical mechanics, quantum mechanics and relativity, which correspond to macrocosm, microcosm and cosmos. A single physical experiment has played a key role in Newton's classical mechanics theory since modern times, which provides an explanation for macrocosm in which we live. However, physical experiments often cannot play a role alone in microcosm and cosmos, because people cannot directly observe the research objects by means of physical experiments in microcosm and cosmos. In fact, even in macrocosm where physical experiments play a major role, there are many cases where physical experiments cannot play a role alone, such as in the study of various electromagnetic fields. In these fields, many phenomena cannot be observed directly with the naked eye, even with various sophisticated instruments, so observational empirical questions cannot be formed. The cognition of these fields often uses the means of indirect observation and then combines with thinking to form an explanation of various indirect phenomena. In 1827, by chance, Brown used a microscope to observe the pollen suspended in the water, and found that the pollen and some other suspended small particles in the water were constantly making irregular curve movement. Later, it was called the Brownian motion. For a long time after that, people did not know the principle. It was not until 1905 that Einstein pointed out based on the principle of molecular motion theory that due to the movement of hot molecules, objects whose size can be seen by a microscope are suspended in a liquid, and movements whose size can be easily observed by a microscope must occur. Brown motion observation experiment using microscope is a typical experiment which based on the physical experiment, and then combined with thinking movement.

Similarly, many thought experiments are often accompanied by material means, in order to make many laws in nature clearly revealed. In Galileo's inertial motion experiment, although absolutely frictionless smooth planes do not exist, we can help people intuitively imagine the possible movement trend of the ball in their minds by using planes with different degrees of smoothness, and the distance of the ball moving above will be different. That is to say, in the process of a series of gradual transformation of the plane from non-smooth to smooth, people see that the distance of the ball moving on it is getting farther and farther, and then let people imagine that a ball moves forward and never stops in an absolutely frictionless smooth plane. The phenomenon of such material means as an auxiliary explanation makes Galileo's thought experiment more intuitive and credible, and enhances people's psychological identity to this experiment. In the coordination theory, as one part of the background coordination force, the thinking concert force must be significantly improved in this case, or this thought experiment puts Galileo's law of inertia in the state of thinking coordination. Therefore, whether in physical experiments or in thought experiments, it is often the combination of material and thinking that works together.

The influence of experiments on theoretical coordination force

The influence of physical experiments on theoretical coordination force

On the influence of physical experiments on the theoretical coordination force, in the book of "Conflict and Coordination: A new Theory of Scientific Rationality", Lei Ma has fully explained this. Experiments are one part of background coordination force. The relationship between experiments and theories depends on the specific situation. "There are some situations in which the theory is affirmed by the experiment, the theory is denied by the experiment, and the theory can neither be affirmed by the experiment nor be denied by the experiment"[7] [7].

Experiments can improve the empirical coordination force of theories. Empirical identity, empirical might, empirical clarity, empirical accuracy, empirical succinctness and empirical diversity are largely dependent on experimental data for analysis and judgment [8]. If the experimental data is wrong, it will lead to doubts about the correct theoretical calculation value, which may destroy a promising theory. Experiment indirectly improve the background coordination force of theories. Laboratory practice directly affects our social practice and political practice [9]. New materials, new equipment and new methods are transferred from the laboratory to the outside world. The effect of the expansion of laboratory

[6] A theoretical empirical problem is derived from the theory, which can generate an empirical problem set.

[7] Lei Ma (2006) Conflict and Coordination: A new Theory of Scientific Rationality, The Commercial Press: 290.

practice makes experimental scientists generally respected, making experimental scientific theories have more technical coordination force, behavioral coordination force and psychological coordination force [10].

Since the advent of modern science, the dazzling light of experiments in science is mainly due to its great contribution to empirical coordination force [11]. In fact, it can lead to the simultaneous rise of multiple indexes of empirical coordination force and background coordination force.

The influence of thought experiments on theoretical coordination force

So far, the influence of thought experiments on theoretical coordination force has been neglected. In fact, although some indexes of thought experiments in the theoretical comprehensive coordination force are obviously not comparable to physical experiments [12]. For example, in the empirical coordination force, and the technical coordination force, the psychological coordination force in the background coordination force, and so on [13]. However, the coordination force of thought experiments is obviously higher than that of physical experiments in the indexes of conceptual coordination force and background coordination force. Thought experiments can influence the coordination force of theories in experience, conception and background.

Physical experiments can improve the empirical coordination force, mainly through the collection of observational experience data. In fact, although thought experiments work in the mind, they can also contribute to the improvement of the empirical coordination force of theories [14]. This function is mainly that people can put forward theoretical empirical problemor through thought experiments, and provide problem-solving ideas for the solution of empirical problemor. Einstein's relativity predicted the phenomenon of light bending [15]. The "light bending" is a theoretical empirical problemor. After the verification through observing in 1917, the "light bending" became an empirical solutionor. Coordination theory holds that empirical problems from empirical observations form observational empirical problemor, and the empirical problems from theories form theoretical empirical problemor. Then, in Einstein's elevator thought experiment, we can ask, When an elevator is in a downward free fall motion, what kind of influence will the gravity of the earth have on the people in the elevator? The conclusion of the thought experiment is "weightlessness". This is a theoretical empirical problem or, which cannot constitute an empirical solutionor. But it can provide clues to solve the problems. Under the guidance of this idea, we can install a spring scale in the elevator, then, when the elevator is in a free fall motion, we can observe the show of the spring scale by some means? Similarly, in Galileo's law of inertia experiment, if the ball moves on a frictionless smooth plane, what kind of state will appear? The conclusion of the thought experiment is "uniform linear motion", although this state does not exist in the real world.

Thought experiments can improve the coordination force of conceptual clarity by clarifying the confusion of concepts in theories. The clarification of the concepts of "faster" and "fastest" makes the conceptual coordination force of Galileo's free-fall motion theory significantly higher than that of Aristotle's theory. In addition, thought experiments can also improve the coordination force of theoretical concept novelty through the introduction of new concepts. Einstein proposed the concept of "constant speed of light" in his light-tracking experiment, which led to a significant increase in the coordination force of his theory.

However, the function of thought experiments is not limited to this. It can play a major role in eliminating the confusion of concepts in the theories and improve the conceptual clarity and coordination force of the theories. It can also propose novel conceptions (for example: constant speed of light) to enhance the conceptual novelty coordination force of the theories [16]. Therefore, the main role of thought experiments is shown in the improvement of the conceptual coordination force of the theories. In addition, thought experiments can indirectly lead to the improvement of thinking coordination force and psychological coordination force in the coordination of theoretical background by affecting people's thinking, psychological acceptance and recognition, so as to improve the comprehensive coordination force of the theories. Therefore, thought experiments can simultaneously affect the three parts of the theoretical empirical coordination force, conceptual coordination force and background coordination force. This is the unique charm of thought experiments.

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Conflict of Interest

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