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THE LINK BETWEEN NECESSITY AND RANDOMNESS IN SCIENTIFIC DISCOVERY
(Constructive Criticism of Karl Popper's Conception)

Abstract

The article is devoted to the problem of the link between the essential and the accidental in the process of scientific discoveries. The authors criticise Karl Popper concept who states that each scientific discovery is entirely "accidental". The authors' viewpoint is based on the methodology of dialectical materialism as a whole, the concept of dialectical determinism, current works on the theory of truth and the criterion of truth. The article treats randomness as the form of being and the phenomenon of necessity. The randomness is presented in the act of discovery by a variety of phenomena such as the particular time, the author of the discovery and the specific aspect of the scientific problem determining this discovery. The necessity here has to do with a specific measure reflecting the limits of change for the phenomenal side of scientific discovery, and this is true for other objective and subjective processes. The authors argue that revealing the link between the essential and the accidental in scientific discovery is a critical foundation for solving all epistemological problems, the problem of the criterion of the truth in the first place.

Keywords: necessity, randomness, determinism, truth, phenomenon, essence, quantity, quality, measure.

Introduction

The problem of the link between necessity and randomness in scientific discovery has been debating in philosophy and science since antiquity. Such a stable interest in the problem is caused by the fact that both the appropriate assessment of the development of society and man and the solution of a wide range of epistemological issues depend on a specific solution to this problem. Some authors absolutised the need for scientific discovery (Laplas, 2011); other authors postulated that a scientific method relies on randomness (Popper, 1957). There is still a pattern according to which some scientific discoveries are characterised as essential while the other ones are treated as accidental (Khodakov, 1964). Sometimes randomness is declared to be a particular major component of scientific discovery and as its unifying factor (Koshland, 2007).

On the one hand, in case if scientific knowledge is the truth-realisation process and the truth is defined as an adequate reflection of objective and subjective realities in our opinions about them, the statement about the absolute necessity

(inevitability) of scientific discoveries is clearly mystical. On the other hand, postulating randomness of scientific discovery leads to a paradox, namely that the process of developing objective reality is essential (otherwise it would be incomprehensible), and discoveries of scientific laws are of accidental character. The aforementioned assumption deprives scientific knowledge of systematic character, and, therefore, of relevant development as any development is a system of directed changes. If based on the postulate of the randomness of scientific discovery, one connects the society's step towards progress with each scientific discovery (Popper, 1957, pp. 17-19), then the history of the society becomes a conglomerate of accidental events, that is, it ceases to exist. In the light of the above, it already seems clear that understanding the inseparable dialectic link between necessity and randomness both in reality and in the cognition of the reality plays an essential methodological and philosophical role.

The preliminary analysis of the discussed problem points to a particular fundamental philosophical concept which constitutes grounds for these or other interpretations of the link between necessity and randomness in scientific discovery. We have in mind the Concept of Determinism associated with non-dialectic approach (Salem, 1996; Laplas, 1982; Schopenhauer, 1992; Popper, 1957; Lem, 2013) and with dialectic approach (G. Hegel, K. Marx). Moreover, as already noted, the theory of truth should be involved for a thorough examination and the solution of the problem under consideration. If according to Popper, the notions of truth and lie are among logical but not empirical categories (Popper, 1982, p. 222), this means that truth is synonymous with logic which leads to the dichotomy between cognition and objective reality. Then what in this regard is the object of cognition?

Methodological Framework

The review of anti-dialectic concepts of determinism leads to the conclusion that only dialectical materialistic concept of determinism can propose algorithms for the solution of the problem of the link between necessity and randomness in determining scientific discoveries. This article is devoted to how it "works".

Pursuant thereto, let us provide a brief overview of the dialectic materialistic concept of determinism. This concept was developed and published as a selected monograph by the author of the article (Ogorodnikov, 1985). The authors' dialectic materialistic concept of determinism is linked with debunking and overcoming three false alternatives which are a serious obstacle to the structuring of the modern scientific worldview as a whole, separate "pictures of the world" (especially the social one) and the methodology of scientific knowledge: Laplacean determinism - indeterminism; necessity - freedom, absolute monism - pluralism.

These dilemmas, for any choice within or between them, do not represent dialectical unity of opposites. They result in metaphysical (anti-dialectical) concepts such as teleology, neo-vitalism, "the theory of factors", fatalism, voluntarism, etc.

The essence of the authors' dialectic materialistic concept of determinism is to achieve the theoretical reconstruction of the system of types of determinations that define the development of any system as the realisation of its capabilities, its embodiment in reality, which requires a distinction between types and forms of determination. The first ones (types of determination) belong to the area of the interaction of different sys-

tems, the second ones (forms of determination) belong to connection status of the various phases and moments of the development of the same system.

The reason as the generating factor is the primary system-forming type of determination of any process. However, a long time ago, the absolutisation of cause and cause and effect as the only type of determination lead Democritus (1968, p. 329) and then, two millennia after him, Laplas (2011, p. 208) to the absolutisation of necessity and the treatment of chance as a consequence of ignorance of the causes. Such a position is the foundation of fatalism and, in fact, all theological concepts. Consideration of how the interaction occurs, determining the relatively active sides of a specific interaction (determinants) allows to reveal the system of causative and non-causative determinants of the process implementing the possibility, such as causal, conditional, functional, inspirational, systemic and controlling types of determinations.

The application of this system to the analysis of any process, including the process of scientific discovery, allows to establish a specific form of manifestation of the dialectical unity of the stable and the variable, the essential and the phenomenal, the necessary and the accidental, the repeated and the unique, the general and the single in the process under research, to avoid metaphysical (antidialectic) oppositions and absolutisations.

In this research, we are mainly interested in the connection between the necessary and the accidental. Until now, this problem does not have a specific solution. So far, many authors try to contrast the necessary and accidental. Some authors present them as different ways to realise the opportunity (Il'in & Mashencev, 2005, p. 57). Other authors claim that, as a consequence of external causes, randomness somehow interacts with necessity (Ivlev, Bagramyanc, & Selyutin, 2008, pp. 250-254). Also being developed, there is still Cournot's (1843) concept characterizing randomness as a result of intersection of independent causal series, and necessity as a result of the intersection of related (until the moment of intersection) causal series (pp. 85-86).

Exactly such oppositions between necessity and randomness are the basis for absolutisation of one of this pair of opposites, K. Popper did, absolutizing the randomness of a scientific discovery. What is the real unity of necessity and randomness?

Approaches to the solution of the problem were laid by G. Hegel (1937), who characterised randomness as a form of being of necessity (p. 298).

Nevertheless, this definition is often interpreted very differently. As we see it, the connection between necessity as an essence, and randomness as a phenomenon (a form of being of the essence) is best considered via the law of the unity of quantitative and qualitative changes, most clearly represented by Hegel in the category of "measure". The law of measure suggests that any property (as an element of quality) of any phenomenon, process, the moment of objective and subjective reality exists within the framework of a precise quantitative measure. The transition across the border of the measure results in a break in quality certainty, a transition ("jump") of the system to a new quality or another quality. For example, the sise, colour, volume, weight of each particular grain of oats and similar quantitative manifestations of quality can vary within certain limits. But none of these indicators can be lower or higher than acceptable level. For example, an oat grain length varies from 8.0 to 16.6 mm. With a greater or shorter

length, the grain loses its essential properties. The grain of the length of 1 mm or 160 cm long cannot exist at all if measure in all processes represents relative necessity, regularity, stability, specific quantitative values of a property within a measure represent randomness as a form of existence of this necessity. So any specific oat grain length from 8.0 to 16.6 mm, say 9.0 or 14, 4 mm will be accidental and will constitute a form of existence of this necessity, represented by the whole set of probable values of the grain length. Such consideration will show that all the reviewed above options for interpreting necessity and randomness demonstrate their absurdity.

Revealing the inextricable link between the necessary and the accidental requires the involvement of the dialectical concept of determinism, the outline of which was described above. We must point out, that all that was said relates, first of all, to objective processes and only secondarily to our views about them.

The considerations mentioned above allow us to undertake a critical review of K. Popper's position concerning scientific discovery.

The Problem and Ways of its Solution

As a starting point of our research, we examine the concept about the methods of scientific knowledge, necessity and randomness in this process which belongs to K. Popper, a famous philosopher and methodologist of the science of the twentieth century.

K. Popper understood dialectics (as well as everything related to any principle in general) as only a method of thinking and a logical device. He did not recognise any objective dialectics as the laws and principles of the development of objective reality, connecting dialectics with consciousness. Hence the contradiction for Popper (2004) is the relationship between opposing judgments, and not the struggle of opposites in objective development (pp. 268-287). Thus, Popper reduces the laws of the world to the laws of logic, the laws of knowledge.

Therefore, Popper does not accept the Marxist concept of historical materialism calling it "historicism" and denies the provision that social existence depends on the laws of development. It is an accidental nature of every step of history that makes, in Popper's opinion, humanity free. The future is not determined by any necessity, but depends on the person, on the progress in the knowledge of the world[1] (Popper, 1975, pp. 24-27). According to Popper (1982) supporter of indeterminism, the history of the society does not make any sense, because it is not subject to the laws. That is why he criticises his former associates who were together with him the members of the Vienna Circle (Wiener Kreis) of Logical Empiricism for using the inductive method. (Popper, 1982, pp. 43-54). In his opinion, induction results in logical errors indicated by scientists starting with Hume as well as in apriorism, since induction can never cover the entire array of the process under study (Popper, 1975, pp. 43-54).

Popper's historical indeterminism is an important foundation of is his heuristic indeterminism. From the point of view of Popper (1975), the main principle of determinism - the principle of causality - means only that any event can be predicted (pp. 83-86). And, according to Popper, since prediction of historical events of the future is impossible, no scientific foresight is relevant. By this statement, Popper makes objective causation dependent on a subjective act of prediction.

[1] According to Hegel, "World history… represents the development of the spirit's consciousness of his own freedom…".

However, not everything that is connected by a causal, objectively-legitimate relationship can be predicted. Prediction requires knowledge of this causal (or any other objectively-regular) relationship. Therefore, the impossibility to predict the future state of any system is not a criterion for the absence or presence of regularity in the connection of the interactions of this system. Popper equates the subjective act of knowing the laws and the objective existence of these laws.

The fact that physicists cannot predict the objective laws that they will discover in future does not indicate that these laws do not exist at all, or that the already known laws do not have predictive, and therefore heuristic force. Predictions maybe not absolute, as in Laplace's determinism, but of relative character because the necessity of history itself (as well as of everything else) is relative. The latter is determined not so much by the subjective factor (knowledge of laws), but by the variability, probabilistic nature of the laws themselves, which do not predetermine anything with immutability and inevitability.

It should be noted that Popper, denying the predictability of historical events, recognises (and builds his argument on this) the impact on the history of the level of knowledge development. But knowledge of what? The knowledge of these same laws of nature and society! For it is possible to can perceive only regular and natural things. At what moment can such knowledge significantly affect the course of history? At the moment which is connected with the possibility of conscious using of the knowledge. Knowledge of this should adequately reflect the objective process and its laws. The possibility of a subjective (from the side of consciousness, that is, expedient) influence on the objective is determined by the presence and regularity of this objective. It is impossible to influence spontaneous processes.

The development of knowledge that Popper recognises is also a natural process, for where there is no direction of change, there is no development. And where this orientation is not understood there could be neither expedient impact on the process nor expedient orientation modification.

Another basis for Popper's epistemological and sociological indeterminism is his postulated fundamental objective distinction between physical, social and biological processes: "Nothing truly new is happening in the world described in physics. Even in a new machine, we can always see recombination of old parts. On the contrary, social novelty, as well as biological novelty, is a genuine novelty" (Popper, 1973, p. IV). The aforementioned can be stated by a specific person who does not understand an evident intraspecific community of plants and organisms, does not know the cellular theory suggesting the common origin and also the unity of the principle of structure and development of the plant world and the animal world.

It is clear that life consistently uses its old "inventions" in new forms of life. In this case, it is enough to refer to the universality of the structural construction of DNA and RNA, the laws of genetics, the laws of natural selection. There is no absolute novelty in wildlife. Absolute novelty is identical to absolute randomness. Like a constructor (although with having better results) nature deals with recombining old "parts" and old structures, old production technologies. In reality, the new quality here is also not reducible to the recombination of the old one, as well as in living nature and society.

Absolutizing the fundamental novelty of each moment of the social process, Popper turns the latter into something non-deterministic - into

a conglomeration of randomness events. Using his favourite trick, Popper proves the absence of laws of the historical process by the fact that, in his opinion, the historical process not predicted. From the subjective "unpredictability" the philosopher derives the objective non-determinism of the historical process. At the same time, Popper constantly identifies the terms "regularity" and "necessity" (in the meaning of "inevitability").

Let us use a contrario reasoning (appeal from the contrary) as a logical technique. Suppose that yesterday's existence of the Russian society has nothing to do with its today's existence, that is, today's existence does not repeat any moments, properties, relationships of yesterday's existence. So, what does it mean? Nothing else but the fact that there is not anything left from the old stage and therefore "today's Russian society" cannot be called either "Russian" or "society". A pattern is repeatability, reproducibility, preservation of some moments of the past in the present and the future. Therefore everything that exists and lasts is regular and logic. Otherwise it is not possible to say about WHAT exists.

In connection with the above, the Popper doctrine can be described as a variant of relativism, absolutising variability in any development process. According to Popper, only something fundamentally new can be the subject of scientific knowledge. The philosopher connects the fundamentally new in social processes with a single event. Following the positivist tradition, he argues that a society's researcher can only ascertain a specific causal relationship for a given single event. Moreover, no scientist can formulate general laws, for each event is unique, random (Popper, 1957, p. 18). As noted above, repeatability and regularity always combine with originality and relative uniqueness, e.g., necessity and randomness, in objective processes. This dialectic must be reflected in the process of cognition of the development of nature and society, between which it is impossible to put up impenetrable barriers, as Popper does.

On the other hand, during the entire postwar period of its scientific activities, the scientist made powerful attempts to debunk induction, as the basis of scientific knowledge. In this regard, Popper, on the one hand, opposes traditional nominalism and positivism empiricism, and on the other hand, considers a separate scientific discovery an atomic (or "singular") random act. There is an apparent contradiction here since if "atomic" discoveries cannot be inductively generalised, then there is no possibility of elaborating a theory. The philosopher does not allow the possibility of transition from the truth of singular statements to the truth of general theory (Popper, 1975, pp. 32-33). Popper (1975) argues that only deduction can be applied in characterising an individual discovery, and induction does not exist in the discovery process at all (p. 40). From his point of view, every scientist comes from general theoretical propositions taken from nowhere, which allows us to explain the essence of a single discovery deductively. This is very reminiscent of Descartes (1989) classical rationalism of, who relied on the theory of "inborn ideas" (pp. 156-158). This also implies Popper's famous Method of Falsification: theories can be scientific provided finding empirical conditions in which they demonstrate their invalidity. Thus, an attempt is made to carry out a mechanical combination of theoretical and empirical probabilities.

However, Popper believes that the validity of a theory can be acknowledged only based on logic. Russian logician V. A. Svetlov (2008) convincingly demonstrated the inconsistency of Popper's criticism aimed at Karnap's theory of induction and proved that a high degree of empi-

rical support for the theory is compatible with a high degree of information (pp. 336-343).

The demarcation of the inductive and deductive pathways of knowledge produced by Popper makes it impossible to realise the inseparable connection between randomness and the necessity for scientific knowledge and scientific discovery. The "absolute randomness" discovery postulated by Popper cannot claim to be objective truth. Progress in scientific knowledge according to Popper is a process of competition of scientific theories on the principle of closeness not to truth, but to "plausibility". Popper tries to find non-empirical criteria for the progressiveness and credibility of scientific theories but does not find anything except his mentioned-above Method of Falsification.

A critical analysis of the necessary provisions of the concept of scientific knowledge of K. Popper showed that in epistemology, as in any other sphere of human activity, it is necessary to base on the dialectical concept of determinism, which considers the inseparable link between necessity and randomness. Otherwise, the researcher strives to absolutise either necessity or randomness of objective reality and the process of its cognition. This leads to a dead-end of scientific research and does not allow to determine the criterion of the truth of the provisions of science.

Mastering truth in the process of cognition is associated with an adequate reflection of laws and patterns in the development of objective and subjective reality. Every law is a relative necessity, implemented within the framework of a specific measure, as a unity of quantitative and qualitative characteristics of developing systems. Each element in the multitude of quantitative characteristics that exist as a measure is a random form of relative necessity being. Therefore, the task of cognition in science is the process of inductive generalisation of a multitude of empirical facts. The ascent from the singular to the universal results in generating a hypothesis. Being an assumption of possible regular (necessary) character of empirically obtained facts, such a hypothesis is verified by deductive descent from the universal to the singular contained in empirical facts. This is how a hypothesis is checked for truth in the process of scientific and experimental practice. Multiple empirical confirmations of a hypothesis under variable conditions elevates it to the level of theory.

However, it must be necessary to distinguish between various types of system determination (causal, conditional, functional, etc.), representing the active aspect of the interaction between various systems. In turn, the types of determination must be distinguished from the forms of the determining process which represents conditions and relationships of stages and moments of development within the same conditions. Forms do not determine the process. Thus, for example, time and space, being not substances, but the forms of substance being, do not determine anything by themselves. That is why it is no good saying about either the direct determination of the present by the past or about the determination of the expenditure of travel time by the distance covered. Such statements return us to the substance concept of time and space and contradict A. Einstein's theory of relativity.

In this context, there are no completely random or "atomic" scientific discoveries. Every discovery is necessarily the discovery of law, that is, it reveals the necessary in the random. Each discovery "fits" the system of discoveries in a particular field of scientific knowledge and in a specific historical period. Besides, a discovery generalises a lot of empirical researches and

trials. When the number of such experiments approaches a specific measure limit there comes a break in the gradual evolutionary process in the development of scientific knowledge. Evolution is followed by a revolution which is the discovery of a new quality of the world. However, the role of creative intuition should not be absolutised. "Intuitive Breakthroughs" are also not accidental. There are many myths about "a random illumination" that befell this or that scientist in this respect.

Many biographers documenting the life of D. I. Mendeleev tell that this outstanding scientist discovered the periodic law of chemical elements in his dream. However, this law was not discovered by anyone else (say, D. I. Mendeleev' janitor Vasily) in a dream. It is quite clear that all such "Intuitive Breakthroughs" are made by not only gifted people but those ones giving many years of their lives to the investigation of specific problems. The example of the discovery of the periodic law repeatedly reveals the dialectical connection of randomness and necessity in scientific knowledge. Firstly, this law became a generalisation of a large number of empirical facts about certain relationships between chemical properties of various elements and their atomic weights. Quantitative accumulation of seemingly random facts led to a new quality, and a new law was discovered. Secondly, the law itself established in the minds of scientists the order in the development of chemical elements, which was objectively inherent in them. The discovery of this law made it possible to predict the properties of the elements that were not yet open and, thus, determined the paths of scientific research in this area. The latter circumstance is the best criticism of the concept of K. Popper, who fiercely fought with the idea of the possibility of such predictions.

Conclusion

Summing up the analysis, we can determine the following main points of determination of scientific discovery, dividing them into objective and subjective ones. The objective determinants of scientific discovery, first of all, include the contradiction between nature and society, which is resolved and reappears in the process of labour activity that produces material and spiritual benefits.

Contradictions within society are also an objective determinant of the development of scientific knowledge. Contradictions determine and stimulate the search, discovery of new facts without which expedient human activity is impossible. Both material and spiritual production, as a purposeful process, is determined by the goal - the ideal image of the future. The goal necessarily includes the ways and methods of its implementation. Therefore, the discovery of the objective laws of the development of nature and society is the most important subjective basis for expedient activity.

The objective stochastic nature of natural and social processes determines the need to consider the process of scientific discovery as probabilistically deterministic. Such an approach reveals the inconsistency of interpretations of the process of scientific knowledge both as absolutely necessary, highly deterministic, and as absolutely random, non-deterministic. The relative necessity is represented by the movement of scientific knowledge from one discovery to another, which reveals an objective connection between different stages of the development of science, the unity of evolution and revolution in knowledge.

REFERENCES

Cournot, A. (1843). *Exposition de la théorie des chances et des probabilités.* Paris: Librairie de L. Hachette.

Descartes, R. (1989). *Rassuzhdenie o metode* (Discourse on Method, in Russian). (Vol. 1). Moscow: Pensée.

Democritus (1968). *Antologiya mirovoi filosofii v chetyrekh tomakh* (Anthology of World Philosophy, in Russian). (Vol. 1, part 1). Moscow: Pensée.

Hegel, G. (1937). *Nauka logiki* (Science Logic, in Russian) (Vol. 5). Moscow: The State Socio-Economic Publishing House.

Ivlev, V. YU., Bagramyanc, M. L., & Selyutin, A. V. (2008). *Metodologicheskaya rol' kategorii sluchainosti, neobkhodimosti i vozmozhnosti v nauchnom poznanii* (The Methodological Role of Categories of Chance, Necessity and Possibility of Scientific Knowledge, in Russian). *News MAMI Moscow State Technical University*, *1*/5, 250 – 254.

Il'in, V. V., & Mashencev, A. V. (2005). *Filosofiya v skhemakh i kommentariyakh* (Philosophy in Diagrams and Comments, in Russian). St. Petersburg: Piter.

Khodakov, Yu. (1964). *Kak rozhdayutsya nauchnye otkrytiya* (As Scientific Discoveries are Born, in Russian). Moscow: Nauka.

Koshland, Jr. (2007). The Cha-Cha-Cha Theory of Scientific Discovery. *SCIENCE, 317*(5839), 761-762.

Laplas, P. S. (1982). *Izlozhenie sistemy mira* (Summary of the System of the World, in Russian) Moscow: Nauka.

Laplas, P. S. (2011). *Opyt filosofii teorii veroyatnostej* (Experience Philosophy of Probability Theory, in Russian). Moscow: Librokom.

Lem, S. (2013). *Summa technologiae*. Minneapolis: University of Minnesota Press.

Ogorodnikov, V. P. (1985). *Poznanie neobkhodimosti: Determinizm kak princip nauchnogo mirovozzreniya* (Recognition of Necessity: Determinism as a Principle of the Scientific Worldview, in Russian). Moscow: Pensée.

Popper, K. (1957). *Poverty of Historicism*. London: Routledge & Kegan Paul.

Popper, K. (1973). *The Open Society and his Enemies* (Vol. I). London: George Routledge & Sons.

Popper, K. (1975). *The Logic of Scientific Discovery*. London: Hutchinson.

Popper, K. (1982). *The Open Universe: An Argument for Indeterminism.* New York: Totowa.

Popper, K. (2004). *Predpolozheniya i oproverzheniya. Rost nauchnogo znaniya* (Supposition and Refutation. The Growth of Scientific Knowledge, in Russian). Moscow: Ermak.

Salem, J. (1996). Démocrite. *Grains de poussière dans un rayon de soleil*. Paris: Vrin

Schopenhauer, A. (1992). *Sobranie sochinenij v pyati tomah*. (Works in Five Volumes, in Russian). (Vol. I). Moscow: The Moscow Club.

Svetlov, V. A. (2008). *Istoriya nauchnogo metoda* (History of Scientific Method, in Russian). Moscow: Academic Project; Business Book.