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ON THE CONCRETE HISTORICAL INTERPRETATION OF THE LOGIC OF SCIENCE

Logic is one of the most important sciences studying science itself. Dealing with the structure of thought, with its laws laws and forms, logic has from the most ancient time touched the very core of science as a system of knowledge and the methods of its increase.

The development of logic is a specific reflection of the achievements of science in its scientific, social, technological fields. The successes of antique science made possible the logical concepts of Aristotle. Bacon's inductive logic was generated by the requirements of the empirical science of the new epoch. The emergence of mathematical logic is inseparably connected with the revolutionary changes in modern science with its general trend towards mathematization and formalization of the apparatus of cognition.

The modern scientific and technological revolution sets up new tasks for logic. The progress of cybernetictics (which is part and parcel of mathematical logic), the rapidly increasing possibilities to endow electronic devices with those intellectual functions which have formerly been regarded as peculiar to the human spirit exclusively, actualized the need to cognize the creative aspects of intellectual activity which so far cannot be reproduced by machines. It is hoped that new logical methods of discovery of the "sufficiently crazy" ideas, will be suggested, by which some fundamental notions and principles of sciences can be changed.

Here we find strong evidence of the inherent connections between the studies in logic and the progress of science. No doubt any science which studies the structure and process of thinking is directly related with the field of scientific cognition. However, the problem of the relations between logic and science has acquired another aspect and became a subject of discussion. This is connected with the growth of the

science of science which is a new direction of the complex studies aiming at a discovery of the regularities inherent in science as a specific system of intellectual production, as a form of human activity, and as a social institution. This trend arose at a juncture of numerous scientific disciplines, each of which has its own specific problems and methodic apparatus and develops its own historical tradition, but each of them deals with different aspects of the same subject, *i.e.* science.

Logic was naturally among the disciplines contributing to the science of science. It is by no means accidental that logic has from its very beginning apprehended the achievements of science and elaborated methods of deducting knowledge, analysing the mental activity and indicating its true or false steps.

The importance of the logical analysis of science has been long recognized; there is no want of such experience. However, doubts arose concerning the possibility to speak of a peculiar character of the logical study of scientific cognition within the framework of the science of science. The prevailing opinion is that the logical analysis of knowledge which aims at the discovery of the regularities traceable in science possesses certain pecularities, and it is suggested *1*) that such analysis be introduced into a new context to realize a synthesis of logic with the history of science, and *2*) that sociological, psychological and other factors affecting scientific advance be considered. However, there exists another opinion according to which traditional logic suffices to cover the problems of the science of science, at least in their principal aspects.

Considering the increasing interest of theoretical thought in science and in the logical, sociological and other studies of its results, P. V. Kopnin says: "Among other disciplines logic is of specific value because it emerges as a form of the science of science." [1]

What is science if considered in its logical aspect? On the one hand, it is a system of knowledge, an aggregate of theories describing and explaining a certain phenomenon; on the other, science embraces definite methods of acquisition of these theories and knowledge. The study of both the former and the latter elements is carried out by means of the terms of reference of logic. If so, is it necessary to speak of a certain "science of science" logic? Provided that the science of science is as ancient as logic, is it necessary to introduce new disciplines instead of developing the existing ones? To answer the question we shall take into account the historical evidence—first of all, the development of logic as such. It is possible to consider the logic of Aristotle, Bacon, Boole—or, generally, any logical system that can be actually operating in the process of thinking—as a theory of the development of science, as a doctrine of the regularities in scientific cognition in the same sense as the

[1] P. V. Kopnin, "Logic of Scientific Cognition", *Voprosy Filosofii*, Moscow 1966.

nascent science of science speaks of the logic of science? We have already noted that all logical concepts correlated their data with science, "worked" for it. But no such concept attempted to analyse the ways, mechanisms, regularities of scientific cognition in the actual historical process. No doubt, Aristotle's doctrine of categories expressed in logical terms the structure of thinking (comprising scientific thinking) of its time. But, employing this doctrine we cannot actually trace the evolution of antique natural science, even if we regard this evolution independently of historical fortuities. We need other methods, another language, another direction of study to reveal regularities in the development of the logical structure of science in antiquity (as well as in any other period).

Otherwise, we are forced to believe that a key-point to the study of the regularities of science lies in the corresponding treatment of the history of logic as a branch of philosophy. To avoid misunderstanding we must be aware of the ambiguity of the term "logic". Logic as a direction of philosophy should not be lumped together with the logic of the very process of scientific cognition, just as the human psychology is not identical with the psychological doctrines of the time.

Developing historical psychology (the science of human feelings, thoughts, desires at different stages of social history) we do not construct it from books on the history of psychology but from other sources. Similarly, the objective historical logic of the progress of scientific thought can be extracted exclusively from its actual development rather than from the reverberations of this development preserved in the history of logical doctrines.

It can be objected that a restriction of the sphere of logic to its basic themes, *i.e.* the theory of deduction and the theory of induction (in their interrelation) and even to the doctrine of dialectic synthesis of categories, is by no means enforced by the nature of the subject of logic; one can state that this sphere may become immensely wider if analyses of any manifestations and forms of thinking are included. If we adopt such broadening conformably to the logic of scientific cognition studied to reveal certain historical ("phylogenetic") regularities in its development, we enter a new field which has not previously been explored by any "science of science" and which cannot be principally coped with unless we employ other than the existing means of logic. The task can be solved only by a co-operative effort of logic and of the history of science. But this logic is thus "another" logic, if compared with the traditional directions of this discipline — namely, this logic is a domain of the science of science.

Entering the science of science we face a variety of complex problems. The correlation between the general regularities in the development of scientific thinking (its general structure) and the realization of

these regularities and structural features in constructing a knowledge of definite spheres of reality in definite historical epochs is one of the most important problems of the field.

This is an unusual approach for traditional logic and a necessary one for the "science of science", *i.e.* objective historical logic. The unity of science as a system does not in the least signify either the homogeneity of all structural and functional components of its complex "organism", or the synchronism of the development of these components. Therefore, the advance of the objective historical logic suggests the construction of some categorial schemes, or—to use the term introduced by Th. Kuhn—paradigms, specific for each domain of knowledge, and the elaboration of methodological principles. This does not signify a break-up of the fabric of scientific cognition, but a specification of the "threads" woven into it. It is impossible to reproduce the logical parameters peculiar to the work of any mind at a certain stage of scientific thinking before the logic of the development of concrete domains of knowledge, *i.e.* the particular sciences, has been generalized.

Here we encounter another new facet of logic, unusual for the traditional variety but definitely obligarory for logic as a part of the science of science. In this connection we must cite an essential distinction between the philosophic orientation of the logical analysis of cognition and its "science of science" orientation; this distinction has been noted by S. R. Mikulinsky and N. I. Rondyi.[2] In the first instance, the structure of science, its achievements and tendencies are analysed from the standpoint of philosophic (outlook and gnoseological) problems; in the second case, the analysis provides for the solution of such problems as the ways of development of the respective sciences, the rise of scientific productivity *etc.* Correspondingly, logic as a philosophic discipline and logic as a domain of the "science of science" perform specific tasks and follow divergent directions.

An objective historical analysis of a concrete science enables the scholar to establish some general structural characteristics peculiar neither to scientific knowledge as a whole nor generally to the science under study, but to the different stages of the formation of this science. To put it differently, we note a phasic character of the historical construction of the knowledge of certain specific objects.

Evidently, this phasic character cannot be established by speculative philosophic deduction of the kind which helped Hegel to construct his majestic system. It can be revealed exclusively if we trace knowledge in the making.

The principles of historical approach and phasic development laid down by Hegel must be purged of their metaphysical and idealistic in-

[2] Cf. the collection *Problems of the history and methodology of science*, Moscow (in print).

terpretation. As a general approach they can be realized in a form consistent with modern scientific values, when the actual progress of thought in a concrete objective content is deciphered by help of them.

The assimilation of the whole historical wealth of a given science is now a necessary condition of any fruitful work in the logic of science. Thus, it becomes evident that the study of the logical structure of science by means of the science of science implies a simultaneous study of the history of science.

However, this is not a traditional but a specialized historico-scientific study. It sets out to reveal the specific features of the categorial structure of thought peculiar to a definite historical epoch. Naturally, the very concept of "epoch" acquires with this approach a definitely new sense it compared to the meaning of the concept in history generally and in the history of science in particular. Traditional periodizations have been guided by criteria different from those from which proceed studies on the logic of science.

Historians of science adopt first and foremost sociological criteria. This is justified in so far as science exists and develops as a function of social life. A logician of science is no more free to ignore the social and historical nature of cognition than a sociologist or a historian of science. Nonetheless, the correlation between the logical-scientific and the socio-historical elements is neither simple nor uniform. A complex system of mediatory factors intervenes. We shall try to demonstrate the importance of this system taking the example of the history of the categorial "network" specific for a special science—that of psychology.

Proceeding from the specific nature of the psyche, which is not an independent entity but a derivative of the interaction of material factors, we shall attempt to trace the emergence and development of the principle of "knots" in the discovery of the dependence of the psyche on what is not psychic, *i.e.* the realization of the principle of determinism.

It is known that the notion of determinism is not uniform. Sometimes it is called forth to designate only the "hard" casual stipulation. In this case the term "determinism" is preserved for the "classical" forms of causal explanation *vs.* the regularities of probability.

We designate by this term the determinational dependence of psychic phenomena on different systems of material influences. In the history of psychological knowledge the principle of determinism has been realizing with a certain regularity; tracing back this regularity we can extract the logic of the development of psychology as a science.

First of all, we can easily distinguish two periods in the development of psychology: the pre-mechanical and the mechanical periods. Up to the 17th century the categorial structure of thinking on the psychic phenomena was conditioned by pre-mechanical determinism prevailing

in different forms in the Ancient East, Greece, in Arabic philosophy and science as well as in the Renaissance. We can distinguish a number of successive steps within this period. But here we are interested in the general principle only. This principle was manifested in a doctrine attributing the difference in sensations, memory, temperament and other items of psychic life to the merging and the displacement of the particles from which all bodies of nature are built. The initial form of causal explanation was only a preparatory stage towards a more perfect deterministic system, which evolved about the 17th century and explained organism as a machine set in action by external forces undestructible under their coercion.

The new concept of organism enabled to interpret its functions, including the psychic function, as resulting from the impact of external stimuli upon internal organization ("the machine of the body").

The possibility of a uniform prediction of the behaviour of physical systems, which had been acquired owing to the categories of new mechanics, inspired an analogous approach towards human behaviour. Its obvious qualitative peculiarities were also deduced from mechanical causes; there was no other road to be taken for the determinists of that time.

The principal psychological theories of the new time: the doctrine of the reflexes, the so-called "causal" theory of perception and the doctrine of association were modelled after the mechanical picture of nature. Descartes was the forerunner of all these research trends. But he was also the forerunner of the introspective concept of consiousness which was the ever-lasting bulwark of indeterminism in psychology. The ability of self-regulation and self-control inherent to the higher forms of human behaviour was regarded as the supreme fact of psychic activity which could explain everything but needed no explanation itself. Thus the two poles emerged: organism, guided by general laws of nature and mechanically interacting with other bodies, and conciousness placed outside of nature. Between these poles scientific thought had been developing until the middle decades of the 19th century. The contradiction between mechanical determinism and the progress of biology had determined the development of scientific notions of behaviour for two centuries (from Descartes to Darwin).

The need to elucidate the principle of determination acting in systems of a higher—as compared with the mechanical—order was urgent. Mechanical determinism was substituted by the general biological determinism. The champions of the causal interpretation of the psyche upheld the biological rather than the mehanical interaction of material bodies; the laws of this type of interaction discovered by Darvin seemed to be as indisputable as Galileo's laws. The new concept of organism and its place in nature became as necessary a step towards scientific

psychology as mechanics had been in its time with respect to biology. It must be stressed that the transformation occurred in the general character of psychological thinking, in its categorial basis.

Whatever psychological problem we approach, we perceive decisive shifts in the methods of argumentation for the causes and mechanism of behaviour and consciousness. The reflectory chord turns form a rigid, morphologically hardened formation into a dynamic characteristic to meet the adaptive demands of organism. Innate features are substituted by those acquired in the struggle for survival in the interpretation of the activity of the sensory systems. The very innate features prove to be a product of adaptation of a species to the conditions of existence.

The new scheme also transforms one of the principal psychological categories—the notion of association. Regarded formerly as a linking of phenomena within consciousness (or brain), it is now interpreted as a linking between external and internal relations, which is in fact a manifestation of objective behaviour (the contact of an individual with external conditions not only by means of metabolism and other biological processes but also by means of special organs procuring information on the external phenomena and realizing control over adaptive actions in conformity with the information gained).

Elements of a new approach that could explain the specific features of psychic regulation of behaviour in accordance with the principles of natural science are discernible in the system of categories peculiar to general biological determinism.

New transformations occur in such basic psychological notions (categories) as reflex, sensitivity association *etc.* The versality of reflex is treated not only as a consequence of the plasticity (adaptability) of the nervous system but also of its dependence upon a psychic component, *e.g.* sensitivity. This sensitivity, formerly viewed among the facts of consciousness open for self-observation, is now placed into the category of signals owing to which the function of distinction of the conditions of behaviour and of its government is realized. Association acquires an objectively meaningful character being converted from an element of the mechanical or purely biological connection into "an element of thought" *etc.*

A new level of explanation of the determination of psychic phenomena becomes evident. I. M. Setchenov was among the first scientists to give theoretical foundations to the new level.

A brief consideration of the development of a science—in this case, psychology—enables to discover the phasic character of its historical advance. Decisive shifts in the general structure of scientific knowledge are characteristic of each phase. These shifts occur in the whole system of psychological notions, models, theories rather than only in a definite group of such notions *etc.* focused on certain problems.

Historical analysis reveals a regularity manifested in a succession of the most general principles and forms of cognition of concrete phenomena. The universal character of the discovered regularity, characterizing the structure of thought and defining methods of construction and transformation of knowledge on the basis of empirical data, methods of investigation, principles of modelling certain processes *etc.*, proves its homogeneity with the regularities operating in the field designated as logic.

Consequently, the logic of science must embrace not only the doctrine of structures (and origin, if we adopt the view of certain authors) of the theoretical, scientifically deducible knowledge in its most general forms. The doctrine of structures, forms and methods of cognitive activity in different objective spheres at different stages of the development of science must also be included into the logic of science.

Let us designate this field the objective historical logic. It is this logic which forms a constituting direction of the science of science. Studies in this field are just beginning, there are numerous problems to discuss; first and foremost, these are such problems as the connection of the objective historical logic with philosophical logic (from which it must borrow and to which contribute something), with the history of science as a whole and of the special sciences in particular. A specialist in a scientific domain is naturally interested primarily in the logic of the development and the extension of "his" science. The instance of psychophysiology cited above proves, however, that the advance of a special science depends on the general scientific progress. The interaction of different, sometimes distant, sciences is not an exclusive value of the present century. Though less intensive and distinct, it can be traced at earlier stages. The objective historical logic of the development of special sciences cannot, therefore, be grasped independently of a consideration of other sciences. Such approach promises information of pragmatic value in cases when we face an outstripping development of the logical structure of some sciences as compared to other domains.

Then the shifts occurring in the former sciences might, to a cerain extent, indicate those to be expected in the latter. The elaboration of the objective historical logic provides for the true strategy of science, it presents no speculative, but historically proved suggestions as to where, not only whence, we are coming. It is thus contributing to the main task of the science of science; its solution is vitally important for a variety of practical issues concerning scientific planning and organisation, training of scientific personnel *etc.*

On the whole, the objective historical interpretation of the logic of the development of cognition appears as the most important component of scientific approach to the "big science" and its functions in a complex social reality at present.