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ON THE LOGICAL ANALYSIS OF THE CONCEPT
"OBJECT OF SCIENTIFIC INVESTIGATION"

The purpose of the present article is to define more exactly the concept of an "object of scientific investigation" by an analysis of the *explicandum* to provide an adequate and exact concept in modern logical theory.

The opinion that the definition of an "object of scientific investigation" is to be formed within each specific scientific research-field and pertains to the competence of specialists in the particular sciences is widely spread.

This viewpoint seems to be the most natural. Indeed, who can know better than the investigator himself what is being investigated? But as soon as the naturalist starts dealing with this problem, he leaves the domain of his specialization and tries to solve gnosiological problems located outside its scope.

Thus, a naturalist, or representative of any specific science, in trying to determine what is science in general, what is his science in particular and what is the object of investigation becomes a philosopher with all the ensuing consequences.

In the history of the development of science two extreme absolutist viewpoints on the gnosiological process have been formed, namely empiricism and rationalism.

The representatives of experimental and descriptive natural sciences are, as a rule, more inclined towards empiricism, whereas those of the theoretical lines of science are rather bent for a realistic conception of scientific knowledge. At closer consideration both lines prove to tell only part of the truth. Since they claim it to be the whole truth, they find themselves on the wrong way of investigation. The empiricist believes that any concept of science is a direct reflection of perceived reality. He maintains that he deals only with facts and trusts only facts. An essential objection against the empirical viewpoint was expressed by Hegel.

Hegel pointed out that in empirical activity directly perceivable objects are transformed either consciously or unconsciously by help of concepts and, therefore, they are not direct.

The reference to "fact" as a basis of scientific knowledge is no evidence in favour of the empirical conception, because the problem of what is and what is not a fact is not trivial and can not be solved without theoretical considerations. The history of science knows quite a number of instances when apparently firm facts proved to be illusions or errors of the investigator himself.

Thus the content of human knowledge is not determined merely by nature. In his *Dialectics of Nature* Engels wrote: "Natural science, like philosophy, has hitherto entirely neglected the influence of men's activity on their thought; both know only nature on the one hand and thought on the other. But it is precisely the alteration of nature by men, not solely nature as such, which is the most essential and immediate basis of human thought..." (*Dialectics of Nature*, Moscow 1964, p. 235).

The conception of rationalism took into account the active aspect of man. But activity itself was taken only as a spiritual, intellectual activity. This, in turn, called forth a special conception of the object of investigation. The object was understood as a rational construction, drawn from the activity of reason itself. That is why rationalism, as a rule, proved to be a form of apriorism too.

The very existence of empiricism and rationalism is to some extent evidence of the difference between the empirical and the theoretical objects of investigation.

In order to analyse gnosiologically the concept of an object of investigation and to state the difference between the object of empirical and theoretical investigation I have to introduce two separate concepts: the object-region of investigation and the object of investigation. Such a differentiation is not of my invention, a similar conception may be found in philosophical literature.

I shall call the set of objects (phenomena) and their interrelations existing independently of human activity the object-region of investigation (A special case of object-region of investigation will be analysed later on in this report.) In other words, the object-region is the material, objectively existing world or some part of it. The objectively existing world contains an infinite set of properties and relations.

It is clear that human activities are limited (in the individual and specifically historical sense). Man is a finite being and is able to absorb only a finite volume of information coming from the external world through his senses. This by no means implies a scarcity of gnosiological possibilities alleged by agnosticism.

The scarcity of human abilities is adequate to the properties of the objective world. No phenomenon or reality ever displays the whole in-

finite set of its properties at any given instant of time. Otherwise there would be no changes whatsoever in the world (existence in the eleatic sense). But this is not the only limitation presented to the object-region. The other one is due to the practical activity of man which, so to say, "introduces" the world to his consciousness from a specific aspect. Consequently, the object of scientific investigation is not the object-world (or its fragment) as it is, but the properties and relations of this object-world fixed by man.

Here the question may arise whether such a situation means a rejection of the objectiveness of scientific knowledge? Not at all, because the isolation of the object of investigation is determined, first, by the properties of the objective world itself and, next, by the peculiarities of practical activity. This guarantees the objectiveness and value of human cognition.

V. I. Lenin noted that "a full 'definition' of an object must include the whole of human experience, both as a criterion of truth and a practical indicator of its connection with human wants" (*Collected Works*, Vol. 32, Moscow 1965, p. 94).

To consider the object of scientific investigation without an analysis of the practical activity of man is senseless, because in fact there is no object outside this activity.

There is no complete identity between the objectively existing world and the object of investigation in the empirical (experimental) gnosiology, but a consonance between the latter and the former should be secured.

Things are much more complicated in analysing the object of investigation in the field of theory. Although there is no complete identity between the object of investigation and the object-world in empirical investigations, still the object is isolated in the process of material practical activity. In theoretical investigations the object is literally constructed, created by the investigator himself. We can find a scientific materialistic explanation of this process in Marx' analysis of scientific investigation.

Characterizing scientific thinking in contrast to everyday consciousness, Hegel pointed out that the former is concrete and systematic. The scientist is not satisfied with stating separate properties and relations of reality, his task is to reproduce all the richness of the relations in the investigated reality and to present the world as a concrete whole. The concrete is unity of multiforms, or, as Hegel puts it, the richness of definitions. To him the concrete seemed to be a result of the development of concepts. Marx showed that Hegel had proclaimed the process of reproducing of the concrete in thinking to be one of creating, one of establishing the concrete. In other words, Hegel proclaimed the specific character of theoretical thinking to be a law of reality, whe-

reas Marx explained the specific character of gnosiology as proceeding from the laws of reality.

The task of scientific gnosiology is to discover laws of reality with a view to change it in correspondence with the needs of man. Reality in itself is concrete, *i.e.* it is a unity of multiforms. In the gnosiological process, however, it invariably appears before man as abstract reality.

In his *Critique of Political Economy*, Marx says that while studying the laws of economic development of society, it may appear as most natural to begin the study with say, population, as it is the most concrete, directly given perception. But this concrete reality appears to the investigator in an extremely abstract form, because he does not see the unity of multiforms (otherwise scientific cognition would be unnecessary). The unity of multiforms is bound to be stated in the process of cognition. It is the stating of this unity in the process of cognition that is the reproduction of the concrete in thinking.

The reproduction of the concrete is a reflection of reality and, as such, differs from the latter in being free from anything accidental or individual that may obscure the regularity of the process. Nevertheless, it does not cease to be concrete. Engels wrote: "The general law of the change of form of motion is much more concrete than any single 'concrete' example of it" (*op. cit.*, p. 226).

Here it should be kept in mind that the laws of capitalist society discovered by Marx are the laws of capitalism in general, and the formulation of these laws becomes possible due to investigations of capitalism in general. Thus, capitalism is a construction of the explorer, a concrete phenomenon reproduced in thinking, it is a reflection of the real material world.

This applies also to the development of the natural sciences. For instance, elementary particles in quantum mechanics are not individualized. This means that theory states laws referring not to empirically discovered individuals but to an abstract object — a particle in general that can exist as an object of investigation only in the form of an ideally reproduced reality.

The preliminary analysis of the concept "object of scientific investigation" enables us to approach the logical problem proper. In the frames of logical analysis we shall use the term "object of scientific investigations" only for denoting the object of theory, and the term "logic" for formal (or symbolic) logic.

Each theory functions in the form of terms and phrases constructed from these terms and interconnected according to some rules. If the theory is meaningful, the construction of sensible phrases and the introduction of new terms into the language of the theory is determined by considerations beyond the scope of linguistics, *i.e.* considerations that overstep the frames of the syntactical description of language.

If the theory is formal and is expressed as some formalized calculus, then the investigator deals with linguistic terms and phrases from a syntactical aspect.

We use "syntactical meaning of a term (phrase)" for a set of rules, determining the place of the term (phrase) in the system of language and its purely linguistic relations with terms of another kind. It goes without saying that the problem of the object of investigation cannot be solved by means of a syntactical analysis of formalized theory. Certainly, one may ask to what extent the properties of objects investigated by this theory can be judged from the syntactical structure of language. There is no answer to this question in general; but in relation to concrete formalized theories it can be quite sensible.

As a rule, the solution of such questions means overstepping the limits of purely syntactical investigations. Moreover, even if the interpretation of the formalized theory is given, the question of how to distinguish by formal (syntactical) properties what is and what is not the denotation (name) of an object in language is not trivial and has no final logical solution.

The construction of logical systems of the type of combinatory logic of Curry and Feys, where any term is an object, is not likely to serve as the criterion of the object of scientific investigations, since the object in calculus must not necessarily correspond to the object of interpretation. The same is to be said about the calculus making use of the operator. Church's abstraction operator is a syntactical method to form an object (or rather the name of the new object), but cannot serve as a logical criterion.

Thus, the syntactical analysis cannot be sufficient, although it is indispensable and fruitful. A more complete analysis may be given utilizing semantical means.

At present there exist several various semantical theories concerning the meaning of linguistic terms. There is no need for us to go into the details of these theories and to confine ourselves to one of them. We just want to point out some essential moments for our analysis.

Let us suppose that we have somehow managed to isolate a group presenting the objects of scientific investigations in language from the set of the terms of language. Every of these terms must be considered as a name. The problem of meaning of a term is modified into the problem of meaning of names. In that case we face the difficulties already referred to by Leibniz (see B. S. Gryasnov, "On Leibniz' understanding of equality and synonymism," *Voprosi Filosofii*, 6, 1965). It was formulated by Frege as the difference between sense and denotation (*Sinn und Bedeutung*).

It is well known that it is easy to construct an example where two names of the same object (thing) cannot replace each other in context

without losing in the volume of information or changing the truthfulness of the statement. This means that two or more names having the same denotation, *i.e.* naming the same thing, can have a different sense. The difference in sense of the terms having the same denotation can be explained as follows. The sense of the term fixed not the object (thing) that is the denotation of a name but only one or more properties of the thing. Such an understanding of the sense of a name may be found in Church's *Introduction to Mathematical Logic*. Since any phenomenon of reality possesses an infinite set of properties, it is natural that several different senses correspond to one denotation. From the gnosiological point of view it is important to point out that sense is not identical with property of the thing, as it is a reflection of property. Using Lenin's definition, we may say that sense is the subjective picture of an objective world. The content of sense is objective, but this content has to be revealed in the object-world through man's practical activity, *i.e.* without man and his practical activity there does not exist what we call sense. It seems to me that a logical analysis of meaning of terms allows us to reveal clearly the meaning of the concept "object of scientific investigation". Some correspondence between the concepts "object-region of investigation" on one hand, and the concept "denotation" and "sense" of a name, on the other, is clearly seen. The concept of sense, as characterized above, is in accordance with the statement of the previous section that the object of scientific investigation in theory is not the object-world itself or some fragment of it but an abstract object — a logical construction. From a logical point of view, this object is the sense of the term and not its denotation.

The validity of such a statement can be proved by means of many examples from the development of science. Let us take one of them — from the theory of sets. In mathematics the concept of "set" is considered to be initial and is not strictly defined. As a rule, it is believed that the meaning of the term is intuitively clear and does not require additional elucidation. It is elucidated by examples of concrete sets. For instance, it is pointed out that a set is a totality of any objects of the outer world, or even of words, concepts, ideas *etc.*

From such an intuitive description of a set and of some of its properties there may arise an illusion that in the theory of sets they mean the denotation of the term "set" when investigating the properties of "sets" and operations with them. The development of this mathematical theory, however, refutes such a notion. As a matter of fact, it is known that in the theory of sets the relation of belonging of an element to a set is not transitive. This circumstance can be explained by the fact that in the theory of sets the term "set" does not mean a totality of elements but a property of this totality, and this is equivalent to the

statement that it is the sense that is dealt with rather than the denotation of the term.

Thus, from a semantical point of view, the object of investigation in theory is the sense of the name.

Since science, especially science in its formalized shape, enjoys a relative autonomusness in its development, a situation is plausible when theory develops with respect to its object (sense), but it remains unknown what actually corresponds to this sense in the object-region.

The concepts of "denotation" and "sense" are strictly fixed only in a given language of science. Proceeding from what has been stated, we cannot suppose that the denotations of terms are necessarily things or objects of the objective world, existing outside the activity of man, and that sense corresponds to the properties of these things. We may use terms either as names of such things, or else for the designation of the words themselves and so on. In the phrase, "the word 'five' consists of four letters", the name "five" appears not as a name of the number but as its own name. This is important for the understanding of the object of scientific investigation in view of the following considerations.

In the process of scientific knowledge the initial object is the denotation of a name; then the object is changed. It is this sense that becomes the object. If the sense of the terms of a theory is formalized, it is possible to operate with the sense of a term as with a thing of the object-world. Hence, a transition to a new level of investigation is possible where the sense of the term expressed in calculus becomes the object-region of investigation. In other words, sense becomes the denotation of new terms. This fact is not always conspicuous enough because a symbol-term may remain unaltered from its material aspect. In fact, this is the case with most terms of science that do not change as words, but change their meaning or the understanding of this meaning. The transformation of sense into denotation results in the corresponding new sense of the terms.

To illustrate such a shift we may take the development of mathematical knowledge. It is well known that mathematics had a long period of pre-scientific, pre-theoretical development. From the gnosiological viewpoint, the object of investigation in that empirical period of development of mathematical knowledge was the object-region from the aspect of quantitative properties and relations and not qualitative relations in a pure form.

The development of theory became possible only when the investigation of the properties of properties began, that is, when quantitative properties and relations were turned into an object. The latter became practicable at the appearance of calculus where the predicator "to be a number" becomes the name of the object and thus the object and thus the object of calculus.