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Organon 8, 5-26

1971

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PROBLEMS OF EMPIRICAL BASIS OF SCIENCE

1. SCHEMES OF THE ANALYSIS OF THE „UNIVERSE OF DISCOURSE"

An obvious postulate of scientific activity is that the results of such activity, i. e. any statements of science refer to something. In other words it is presumed that statements made by science have not only a meaning, but also a denotation, i. e. that they refer to a certain orbit of objects the aggregate of which we shall term a universe of discourse. What we have here in mind is not the universe of discourse of science in its entirety, in all the historical development of science. Such a universe of discourse can naturally provide an object of philosophical meditations. In our reflections, however, we shall always speak of the universe of discourse as of a limited region, specified in a certain manner, which is *inter alia* also relativised by a certain province of science, a science taken always at a certain stage of its evolution. This also implies that the universe of discourse so conceived must be regarded as a part of the world at large. This also implies that this universe of discourse can be extended to include new objets, not reckoned within the original delimitation of the universe of discourse.

From the formal point of view the universe of discourse is a certain non-empty set of objects characterised in a certain manner. What is therefore always needed is a definite criterion that would enable us to decide whether any object is, or is not, an element of the given universe of discourse, and whether it is therefore essential to take into consideration this element when analysing the universe of discourse. In science, the criteria for these decisions can assume diverse characters: For empirical and experimental sciences, these may be, above all, empirical or experimental criteria. We consider it a matter of course that biology treats of phenomena of *live* nature, that thermics studies *thermal* phenomena, accustics the *acoustic* phenomena, and so forth. It may

certainly be pointed out that the attributes "live", "thermal", "acoustic" can be regarded as empirical attributes only in the common language, whereas in contemporary science, we by far do not consider these or similar attributes as purely empirical or even as discernible by man's sensory activities. A similar objection is entirely legitimate. In the development of science we frequently witness how, in the course of the specification of the universe of discourse of a discipline of science, numerous originally purely empirical criteria gradually change their meanings, how in science theoretical criteria are taken into consideration in an ever increasing measure. The majority of the criteria that originally operated as empirical criteria, are thought of as theoretical criteria in contemporaneous science. Due to this development, many of the theoretical criteria are at present very remote from the originally purely empirical criteria. If, for example, we delimit the scope of our investigations by stating that we shall be concerned with "phenomena of non-linear oscillations", we shall not be in the first analysis concerned with an answer to the question whether we are facing electromagnetic, mechanical or other oscillations, but on the contrary, we shall aim at those common theoretical characteristics which are being shared by empirically entirely different provinces. Analogous thoughts can be formulated with regard to processes of management, information processes and so on, inasmuch as here as well what is in the forefront of our attention is the structure of these processes, their adequate expression by the corresponding mathematical formalism, and not the empirically heterogeneous facets of the systems within whose frameworks the processes of management and communication processes come into play. The criteria for the specification of a universe of discourse can also have a conventional character. When studying the properties and the behaviour of systems of constructive elements, for instance, of the Turing machines (which have not been, and basically cannot be, either technically or empirically implemented), it is expedient to lay down, in advance and on the strength of a convention, which objects shall be included into the respective universe of discourse.

In science, in the specification of the given universe of discourse, we are basically unable to establish the priority of certain criteria over others. Although we are witnessing a situation where the selection of these criteria is to an ever greater extent dependent on theoretical conclusions and also on theoretical aims, pragmatical considerations are gaining ground here as well, considerations determined, above all, by an answer to the question what the given inquiry serves or ought to serve. In the progress of science we experience a reciprocal effect of what is being referred to as the "object of science" and what forms the complex of methods, discoveries, theoretical and experimental means of a given science, including the goals at the attaining of which

the use of these means is aimed. The selection of the universe of discourse no doubt influences the choice of the methods, theoretical and experimental means and so forth—on the other hand, however, the complex of these methods and means substantially influences the specification of the universe of discourse. Such reciprocal influencing and the consequent gradual changes in the specification of the universe of discourse appear very clearly in the development of certain fields in the physics: When accoustics first formed and was later developed, it was at first concerned with the study of the phenomena that could be registered by the human ear. The first steps in the specification of the universe of discourse were obviously founded here on a purely empirical criterion. However, a further study of acoustic phenomena, the study of the oscillations, the discovery of the Doppler effect as well as further advances in this field not only caused such phenomena that could not be discerned by the human ear to be included into the original universe of discourse, but also brought about fundamental changes in the original criteria for the specification of the so-called acoustic phenomena.

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So far, we have been considering the universe of discourse solely by presenting an outline of certain problems of external specification of the universe of discourse. However, of no lesser importance to the methodology of science are also the issues connected with an internal analysis of the universe of discourse. It is evident that such internal analysis depends primarily on the nature of the universe of discourse itself. In our further account we shall turn our attention to some of the more essential schemes of the analysis that can be applied particularly to empirical and experimental sciences.

Basically, we must point out that certain elementary schemes of internal analysis of the universe of discourse which we encounter in empirical and experimental sciences are due to common sense, and originate in some categories of the current language.[1] This is especially the case with the scheme "thing—property", (or the extended scheme "thing—property—relation"), but after all with further schemes as well: the "situations" scheme in the universe of discourse, and the "events" scheme. Let us now inquire at some length into the individual schemes, and into certain logical and methodological links between such schemes. Their strict distinction is of course being carried out solely in view of the need for a more detailed analysis—in the common language and current thinking such schemes are intertwined and mutually supplement each other.

[1] These relations were analysed, in particular, by S. Körner [KÖRNER].

(*a*) One of the most current schemes of the internal analysis of the universe of discourse is the scheme "thing—property", or the more widened scheme "thing—property—relation". Let us however underline the fact that in this connection we shall not go into the details of the traditional ontological complex of problems, which the philosophical literature concerned with these concepts has hardly succeeded in clearly ordering, but shall focus our attention exclusively upon those questions that are related to the analysis of the universe of discourse and the development of the language of science.

The scheme "thing—property" is anchored in the common language, and is based on the most elementary version of empiricism: we are in a position to distinguish various „things" about us by differentiating the "properties" of these things, the simplest version of such differentiation being the sensory differentiation. In this most elementary form the notorious dispute about the priority of the thing or the property does not arise as yet. Such a dispute only arises as soon as we begin to ascribe to this scheme more profound philosophical and especially ontological contexts.[2] If we centre our attention upon the formal aspects of the said scheme, and confine ourselves to the most general determination that the "thing" is an object (individual object) in the given universe of discourse, then it is true of any one thing that it is possible to state *something* about it. This "stating something" about a thing we usually interpret in such a way that to an individual thing, an ordered pair, a triad, a group of n things we assign certain properties.

The most convenient logical forms for the expression of the said scheme are therefore supplied by the logic of predicates. The universe of discourse is here a (non-empty) class of (individual) objects. The predicates we then regard as names of the properties of these objects, and also as names of the properties of ordered pairs, triads, groups of n objects, hence also the names of relations between objects. The scheme "thing—property—relation" which relies upon common sense and a most elementary version of empiricism, can thus be explicated by those means that are provided by predicate logic. With respect to any predicates, the universe of discourse can be partitioned into subclasses of objects, ordered pairs, triads or groups of n objects, to which the given predicates could or could not be assigned. Naturally we cannot out that some of these subclasses may be empty. This also means that the said scheme, which we have explicated by means of predicate logic, permits us to develop a dual interpretation of the role of predicates: an

[2] Carried to ultimate consequences, the concept of the „thing" is an abstraction in a similar respect as the concept of „property". What we are faced with is merely that in the continuum of discernable phenomena we have a tendency to regard some of these phenomena as „things", and others as „properties". Nor can we rule out whatever we shall term a „thing" in one context, we shall call „property" in another.

interpretation of the role of the predicates as names of the properties of objects (or ordered pairs, triads or groups of n objects), this version representing, from the semantic viewpoint, the intensional aspect of this interpretation, and an interpretation of the predicates as names of the classes of objects (ordered pairs, triads, groups of n objects), this latter version representing the extensional aspect of this interpretation.

The concept of "predicates" can be considered as a name of any property of objects or their ordered pairs, triads or groups of n objects. In this connection we may be confronted with properties discernible empirically, or with properties that can be discerned on the basis of other criteria. It cannot be ruled out, either, that the class of those objects that will arise from the given universe of discourse by application of a certain predicate will be an empty class.

The explication of the traditional scheme "thing—property—relation" by means of a language founded on the logic of predicates is able also to solve the problem of relativity in the relation "thing—property". From the natural language we have learnt that it is possible to "state something" about a class or a property as well. Also in the language of science it is mandatory to take into account a situation where the statements formulated by science do not refer to the objects alone of a universe of discourse, but also to classes of these objects, their properties, etc. From this angle it is indispensable to distinguish predicates as different types, i. e. to take into consideration what was brought into logical thought by the theory of types.

The predicates are furthermore presumed to be capable of expressing all the properties of, and relations between objects, i. e. for example empirical and theoretical properties, qualitative and quantitative properties, temporal and spatial, invariable and variable properties, etc.

(*b*) Another scheme of internal analysis of a universe discourse is one that can be best characterised as a "situation" scheme, a scheme of "temporal and spatial regions", "fields", and so forth. In the case of the scheme "thing—property—relation" the analysis of the universe of discourse can lead us as far as the individual objects. Here we therefore presume that either we shall have at our disposal certain principles of individualisation, or the individual objects are the actual starting-point of the specification, of the internal analysis and the partition of the entire universe of discourse. In the case of the "situations" scheme, there is no need to postulate that through the medium of an analysis of the universe of discourse we shall reach individual objects.

In the current language, the question "what is the situation?" (this question being normally understood as "what is the situation in a certain assumed or delimited space?") is usually answered by characterising the distribution of certain parts of the universe of discourse, their

reciprocal relations, and the like. The question "what is the situation?" (it being understood that what is meant here is the "meteorological situation" in a definitely assumed or defined region) will be answered by the meteorologist to the effect that in one part of the contury it is raining, in another the sky is overcast, and in still another sunshine has been registered. A question aimed at the situation on the battlefield shall be answered by the staff officer by offering a description of the distribution and location of the forces of his side, combined with the information on the location of the tanks, infantry, etc. of the enemy.

It may seem that the "situations" scheme represents a certain modification of the scheme that is founded on the relationship between the categories of "a part" and "the whole". Such a contention is however only partly justified, namely in so far as by "the whole" we understand the entire universe of discourse. In the event of the "situations" scheme it is typical that we have in mind the relation of the given region, the given field—to the entire universe.

The "situations" scheme can be best explicated by means of the language which is based upon the logic of the classes (or those mathematical means that are supplied by the theory of sets). What is involved here are in particular diverse possibilities of operations concerning classes, the relations between classes, and the like.

Although, as we have already pointed out, in the case of the "situations" scheme there is no need to postulate that the analysis of the universe of discourse shall be carried through down to individual objects, on the other hand it is not necessary either to rule this out entirely. We must bear in mind that individual regions or fields also consist of individual objects, and that we are obviously not always capable of achieving a complete differentiation of these individual objects. The essential feature consists in that these individual objets can be considered as elements of the given class.

In this connection it is expedient to discern two degrees of individualisation:

(*1*) The elementary degree of individualisation consists in whether we are able to prove that the object being considered does or does not belong to a certain class.

(*2*) A higher degree of individualisation consists in whether we are able to prove that the object being considered does or does not belong to all these classes that we are able to distinguish by means of a partition of the universe of discourse.

These two degrees of individualisation can also be expressed by those means that are offered by the scheme "thing—property—relation". In the former event we are able to prove only one property of the object. In the latter event we are able to prove all (known, accessible) properties of the object.

From the methodological point of view the differentiation of the two degrees of individualisation is most important. In medical diagnostics, an example of the first-degree individualisation is a statement that the patient that is being examined has influenza. A similar statement has already a practical importance and can affect the measures to be taken, such as the choice of therapy. However, for a more thorough examination of the patient and a more perfect decision-making about an adequate and effective therapy such a statement is insufficient. What is needed is to pass to a higher degree of individualisation, i. e. an investigation as to what further properties the object under examination exhibits, or—which is just another way of expressing the same postulate—to which of the other classes the object under investigation could or could not be assigned. In our instance we may, for example, be faced with the task of ascertaining other diseases the patient is suffering from, with the problem of widening the orbit of symptoms which we shall reckon with when establishing a more exact diagnosis, and so on.

As is clear from the above account, the "situations" scheme can be well converted to the "thing—property—relation" scheme. This is also apparent from the mutual relationship between the two methods which are linked with the "situations" scheme, i.e. the method of the structure description and the method of the state description. [3] When describing a structure we presume that the given universe of discourse has been partitioned into a (finite) number of classes. The description of the structure then consists in the *determination of the numbers* of individual objects, ordered pairs, triads or groups of n-objects belonging to individual classes. When describing a state, we presume, in addition, that we are in a position to discern all the individual objects. The description of the state then consists in determining *which definite* individual objects, ordered pairs, triads or groups of n objects can be assigned to individual classes. If we give a description of the structure or, in addition of the state of the given universe of discourse, we provide a certain picture of the situation of the given universe of discourse.

(c) With regard to both above-said schemes of internal analysis of the universe of discourse we normally presume that we are capable of overlooking or clearly specifying the entire universe of discourse. [4] Con-

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[3] The elementary ideas of the method of state description were developed by L. Wittgenstein [WITTGENSTEIN]. As to the formal aspect, the method of state description (as a starting point of semantic analysis), as well as the description of the structure were detailed especially by R. Carnap [CARNAP].

[4] This also applies to the scheme „thing—property—relation". If for instance we are in a position to apply to the given universe of discourse three properties expressed by one-place predicates P_1, P_2 and P_3, we can in that manner partition the universe of discourse into a total of eight classes according to which of these properties have or have not objects of individual classes. Some of these classes may of course be empty.

trary to this, with another scheme that we encounter frequently both in current life and in science this postulate is not fulfilled. If we state that "it is raining here now", we do not establish the meteorological situation in the whole of our geographical region, but merely make a statement in respect of a certain event, at a certain time and in a certain place. The scheme of such statements concerning the universe discourse can be refferred to as "events" scheme (or "facts" scheme).

The most suitable explication of the "events" scheme can be supplied by the language of the propositional calculus. If we consider as a statement any correctly formed expression about which we can decide whether it is true or not, then that which from the semantic angle corresponds to the statement can be termed an event. In that case the universe of discourse is formed by all the possible events, i. e. by all that about which statements can be made. If we have two statements, say a statement r (it is raining), and a statement m (there is mud) than the truthfulness or untruthfulness of these statements, or any statements arising from a combination of the former statements will refer solely and exclusively to the given events, regardless of any consideration for the entire universe of discourse.

The "events" scheme is often made use of to express the results of observations, measurements or experiments, especially if the statement has the character of protocol-statement, or a definite statement of facts. As an elementary form of protocol-statement we may regard the sentence: "In a given place and at a given time the observer (experimenter) has established such and such a thing." It is evident that this statement does not give any information on the events that took place in other places at another time, nor does it give any information as to what the observer had established in the same place previously, or at the same time in another place. Further protocol-statements would be needed to establish such further events.

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The three schemes set out above of the analysis of the universe of discourse evidently do not exhaust all the possible schemes that we can encounter in current language and in the language of science. However, they represent the most frequent and it seems also the most important modes of handling what we regard as objects of the cognitive processes in empirical and experimental sciences. The results of these cognitive processes can be expressed in diverse schemes, not ruling out the possibility to express the same result by means of various schemes, or the possibility of reducing one scheme to another scheme.

It is also natural if with respect to each of the said schemes we meet with some problems, complications and difficulties of semantic and ontological nature. Seeing, however, that this work is not aimed at

a more detailed analysis of the questions of this kind, we shall confine ourselves to some selected examples of such problems.

In the scheme "thing—property—relation" we make statements on individual objects, either definite objects, or some objects, or all the objects having the given property, and the like. We therefore presume "the existence" of these objects. Is it, however, legitimate to presume, in the same sense, also the existence of classes of these objects, the existence of properties of, and relations between these objects? While the concept of "existence" is multivalent and can be interpreted in diverse fashions, such a question or similar questions can be the object of disputes and discussions. [5] Analogous problems also arise in the "situations" scheme, especially if we explicate this scheme by means of a language based on the logic of classes.

Also in the case of the "events" scheme some problems arise, and become the object of discussions and disputes. If we issue from the said explication of the "events" scheme by means of the language of the propositional calculus, and assuming that we respect the postulate that a statement is any correctly formed expression about which we can decide whether it is truthful or untruthful, then we most often meet with the problems expressed by the following questions:

Which are the criteria of a "correct formation" of linguistic expressions? (In particular are these criteria predominantly syntactic or also semantic, or in addition pragmatic as well?) If what corresponds to true statements is what we refer to as "events" or "facts", then what is it that corresponds to false statements? It is clear that this latter question can only be posed if we accept what has been stated in the antecedence, i. e. a "fact" or an "event" corresponds to a true statement. Can we take the circumstance that what the statement expresses did not occur or is not occurring also to be an "event" or a "fact"? Also in the investigation of these problems the corresponding specialised literature offers a variety of conceptions.

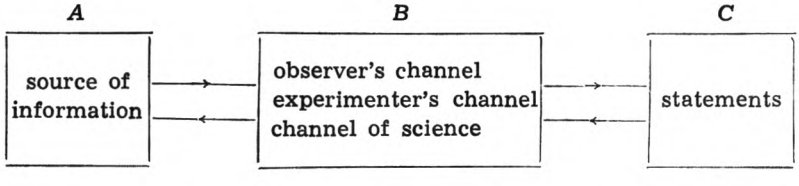
Although the problems of this kind can by no means be underestimated, the investigation and solution of substantive methodological disputes can on no account be reduced to disputes over the priority of one or another ontological approach. For this reason, in our fruther account we shall devote to these problems but the strictly necessary interest, while focusing most of our attention upon problems of typically methodological character. In order to simplify the analysis of these problems we shall depart primarily from that analysis of the universe of discourse which is based on the first of the three schemes.

[5] Although this or similar questions form a certain complex, there is still a difference in the formulation and interpretation of these questions between nominalism, platonism and conceptualism, or between what corresponds to these conceptions in contemporary mathematics and logic. These mutually differing conceptions naturally submit substantially differing answers to questions of this kind.

2. COMMUNICATION MODEL AND THE PROBLEM OF SCIENTIFIC EMPIRICISM

Any results of the cognitive activity in science can be communicated only through the medium of language. Therefore, they assume the form of statements of language; at the same time we always presume that these statements refer to something, or, in other words, that they have a meaning, that they can be semantically analysed. This semantical analysis is supported either by the results of certain procedures (for example observation, measurement, experiment and the like), or by other statements (for example statements indicating the results of the said procedures, statements of theoretical character, axioms, theorems, and so forth). In any case, statements expressing the results of a cognitive activity have a *mediated character*. This mediation consists in that the objects of the universe of discourse, be they objects discernible by our senses or constructive objects to which we refer the statements, can only be reached by means of certain procedures.

For an elucidation of the above-mentioned mediation we can use to advantage the communication model, which presupposes communication connections of a minimum of three blocks: (*A*) the block of the "source of information"; (*B*) the block of "the observer's channel", of the "channel of the experimenter or the measuring equipment" or still more generally "the channel of science"; (*C*) the block of "statements". Schematically the connection between the three blocks can be sketched as follows:



Block *A* can be visualised as a (finite or infinite) set of events in time and space, objects of most diverse nature, and the like. In this connection we assume that at least some of these events or objects can be discerned by means of block *B*. In other words, block *A* is made up of a set objects of most varied nature, but such objets as can be taken as distinguishable stimuli for block *B*. We may for instance be faced with a set of sensorially discernible objects which can be observed provided block *B* is a human observer. We may also be facing a set of objects that can be reconstructed as (hypothetical) causes of certain reactions of block *B*, for instance, a set of diseases calling forth certain discernible symptoms, movements of microparticles which call forth certain discernible traces in the measuring or experimental equipment, and the like.

Block *B* may be represented by a human observer, or possibly an observer fitted with equipment augmenting the power of the senses to discern (e. g.: a microscope, telescope, a measuring equipment, etc.) or finally any measuring or experimental equipment able to register the stimuli coming from block *A*. If we say that block *B* is able to discern the stimuli coming from block *A*, it does not always imply that block *B* is able to discern all the stimuli coming from block *A*, or to discern them absolutely adequately. Between block *A* and block *B* we presume the existence of an informational link in which naturally also noise may appear. This noise may influence the extent of inaccuracies, mistakes or errors which characterise the reactions on the part of block *B* to stimuli coming from block *A*.

The properties of block *A* and those of block *B* mutually differ in important respects: While block *A* may consist of an infinite set of objects or events, and therefore can generate an infinite multitude of stimuli, block *B* is able, in a definite time and within a definite space, always to register only a finite amount of stimuli. The problem of methodological finitism is therefore anchored in block *B*, and not necessarily in block *A*. For block *B*, in addition, *certain thresholds* are always characteristic between which the latter is able to discern the stimuli coming from block *A*. A finite and limited degree of attainable discernibility is also characteristic of block *B*. Thus definite *limits* are always set to the activity of block *B*.

Apart from the limits of this kind, other limits may be presumed, the limits related to the possibility of an (uncontrollable) retroaction of block *B* upon block *A* (in the block scheme the possibility of such retroaction is indicated by a two-directional connection between *A* and *B*). In the development of scientific discovery the limits of this kind were encountered in the quantum theory, where they were formulated in the from of the uncertainty relation: If the measurement of the position of a microparticle can be accomplished with accuracy Δx, and if a simultaneous measurement of its impulse can be accomplished with accuracy Δp, then the well-known relation applies:

$$\Delta x \cdot \Delta p \geqslant c,$$

where c is a quantity of an order corresponding to Planck's constant. Analogous relations were also formulated for other pairs of physical quantities. It is obvious that with the aid of the means of block *B*, the state of block *A* can only be represented up to certain limits, these limits being also given by a retroaction of block *B* upon block *A*. (In the interpretation of the uncertainty relation it is for example assumed that block *B* is represented by an electron microscope. Then the measurements of temporal and spatial and impulse-energy parameters of the

object to be measured can be-if we come close to a certain limit—affected by the beams employed in the electron microscope.)

Another form of such limits, analogous to Heisenberg's uncertainty relation has been pointed out by D. Gabor [Gabor, p. 429], in the analysis of acoustic measurement. If the signals are being measured by means of an equipment with a band width ΔF, then the shortest signal that can be measured is ΔT, the product of ΔF and ΔT being greater than or equal to the constant of the order unit.

It is natural that the feedback between block B and block A may have a greatly diversified character. It can, for example, manifest itself as an energetic action by the measuring equipment upon the object being measured, it may change the states of the object to be measured in such a manner that on the output of block B we shall not receive information which would permit us reliably to estimate state A, but shall receive information about a modified state A, this latter state differing from the original state, in which the feedback between A and B has not occurred as yet.

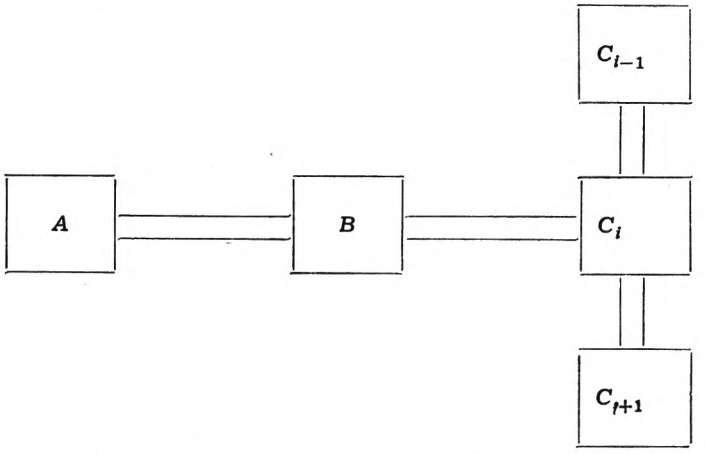
The said analysis of mediation, which relies upon the communication model, may have a very general meaning, which does not have to be confined to measurements in natural history or technical measurements. The following thought shall bear out the above postulate. Let us assume that we organise a sociological research of attitudes, of public opinion, of a prestige scale, and so on. When working on the questionnaire or the corresponding inquiry we may of course formulate some of the questions so suggestively as to influence the attitudes of the respondents to some degree. It will, for instance, suffice to resort to certain terms of emotional meaning, it is possible to select certain questions in such a way that they can influence a certain kind of answers, and so forth. Also in such a case block B shall influence the original state of block A in such a manner that the information that we shall receive on the output of B shall not be adequate to block A as such, but will be the result of interaction between block A and block B.

Both block A and block B are presumed to have structures of their own: this means, for instance, that the measuring equipment through the intermediary of which we obtain the required data concerning the object under investigation does not have to exhibit the same character as the object to be investigated, that it may have its own independent structure, and the like. Evidently in this connection block A is presumed to exist, or is given as objective for the purposes of the respective investigation, i. e. block A is independent of block B. On the other hand, it is equally uncontroversial that any statements in respect of anything concerning A can be formulated only and exclusively on the strength of the data that are available on the output of B. This also implies that to scientific empiricism are inacceptable any reflections founded

on some kind of non-mediated "penetration into the essence of things", "visualising the essence", "intuitive comprehension of the essence", and the like.

Of block C it is true as well that it has an independent structure of its own: It is a system of statements based on the one hand on information supplied on the output from block B, on the other on further statements that have been included into the given system from other sources. In principle we are faced with a twofold mediation, which was already pointed out by B. Russell, who made a distinction between "knowledge by acquaintance" and "knowledge by description". Knowledge based on direct experience is therefore understood here as a mediated knowledge as well, a knowledge mediated through block B, regardless of whether this block comprises the human observer alone provided with the normal sensory outfit, or, in addition, also with measuring or experimental equipment. Knowledge on the basis of descriptions can of course be likewise founded on observation, measurements, experiments and the like, but he who disposes of block C, gains this information (in Russell's terminology: these descriptions) from communication processes with other people; scientists, experimenters and others.

Schematically we may represent this dual mediation by a crossing of two communication processes:



The relations between C_{i-1}, C_i, C_{i+1}, etc. can be interpreted as current communication processes between two or more communicants. These may comprise, for example, a dialogue, the relationship between author and reader of a scientific study, the relations between lecturer and student, and the like.

If we say of block C (and evidently also of any of the further blocks, i. e. of C_{i-1}, C_i, C_{i+1}, etc.) that these consist of statements, it means that in the formulation of these statements we must observe the respective syntactic, semantic and other rules, which are binding for the language

in which the statements are formulated. The above-mentioned characteristic, i. e. the stress on the relatively independent structure of block *C*, applies also in this respect.

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The said communication model which underlines the twofold mediation permits a new, more fruitful interpretation of certain traditional concepts of which we avail ourselves in the analysis of the statements of science. These are, in particular, the concepts of "assignment" (in the semantic sense), the concept of "level", and the concept of "experience".

Let us first pay attention to the concept of "assignment". Normally we encounter the term in a plain, and to some extent naïve question "what corresponds to?" This question actually postulates that the elements of block *C* be simply assigned to elements of block *A*. The naïveté of this question follows clearly from a more detailed analysis of the vocabulary employed for the statements: Some elements of the vocabulary obviously have the character of logical terms (in Russell's terminology of "logical words"), in which the question "what corresponds to", especially a question that would call for an immediate assignment of all the elements of block *C* to elements of block *A*, can never lead to a satisfactory answer, for the question has simply been wrongly formulated. Disregarding the logical terms and confining ourselves to extra-logical terms, we are actually confronted with the traditional problem of denotation. This problem, which naturally presupposes a certain assignment of the elements of block *A* and block *C*, cannot however be solved in all instances by a one-one assignment, as would be required by the naïve question "what corresponds to?" This applies in particular to those elements of the statement that have a character of theoretical concepts having the form of two- or many-placed predicates, etc. It is for example possible to interpret some of the theoretical concepts as expressions stating certain links between empirical concepts: The concept of specific gravity expresses a relationship between the weight characteristic and the volume characteristic of a given substance. Hence, although in respect of those elements of block *C* which have the character of extra-logical terms it is legitimate to ask the question aimed at denotation, it is nevertheless naïve to interpret this question always as a question "what corresponds to?" We must take into consideration the fact that in the case of a denotation we are not always facing a one-one assignment, and in addition we must respect the fact that in this assignment the mediating role of block *B* is often brought into play.

The semantic properties of any expressions that we take as elements of block *C* cannot of course be reduced to denotation alone. Besides denotation, this being of particular importance in the communication pro-

cesses between C_{i-1}, C_i, C_{i+1}, etc., i. e. in what corresponds to Russell's conception of knowledge based on description—the meaning of the expressions asserts itself. The fact that expressions have meanings permits us to comprehend them. From the standpoint of the communication processes between C_{i-1}, C_i, C_{i+1}, etc. the meaning is what is preserved in any reliable communication between C_{i-1}, C_i, C_{i+1}, and so on.

An important problem upon which attention must be focused when conducting a semantic analysis of the language of science is the problem of the so-called level, and selection of the appropriate level for assignment. If we assume that block *A* is formed by certain elements, we must take into account the possibility that these elements can be categorised, hierarchically ordered in a certain manner, etc. Here will also be brought into play what we have characterised earlier as various schemes of an analysis of the universe of discourse. Applying for example the scheme "thing—property—relation", then we can (but this will be a reconstruction *ex post* of its kind) reckon with such a conception of assignment that assigns "things" to individuals, "properties" and "relations" to predicates, etc. Similar to other schemes, here, too, the legitimate question arises in how far we actually do not attribute whatever is specific to block *C* also to block *A:* in other words, we might be apprehensive lest the structure that is specific to the language and the statements of language be not imputed to the universe of discourse itself. In any reconstruction of block *A*, and generally in any reconstruction of the universe of discourse we must therefore also take into consideration that between blocks *A, B* and *C* feedbacks begin to operate, which may however also take the form of a direct influencing of block *A* by block *C*. This means that in this reconstruction we must advance most judiciously, control every one of the steps we take and cofront the results of each of the steps. In particular, it is mandatory to avoid naïvely realistic illusions usually reflected in the efforts to assing "something" in block *A* to any element in block *C*.

The emphasis on the fact that block *C* possesses a relatively independent structure of its own can also be taken in the sense of a hierarchically ordered structure. If we have said that block *C* is formed by statements, we must take into account that in formulating any statements we must use extralogical terms of the language, or a combination of extralogical and logical terms of this language. These statements, in the formulation of which the respective rules of the given language shall be observed, may form certain complexes, and so forth. In this way we shall attain a question that could be formulated as follows: With respect to which category, on which the formulation of the statements or a complex of the statements is founded, are we entitled to consider an assignment? If, as we have mentioned we are normally inclined to assign to individuals and predicates certain things, properties and relations, are we

entitled to consider, in a similar fashion, the assignment of other, especially the "higher" categories? The traditional logico-semantic investigation of the problem of denotation, according to which individual objects are assigned to the names of individuals, while classes of individual objects or classes of ordered pairs, triads or groups of n objects are assigned to predicates, actually considers the relations between blocks A and C only at this level. If for the denotation of the sentence we take the truth value, i. e. the entity of constructive nature, we have already exceeded the framework of the relations between blocks A and C. (This also applies to other attempts to solve the denotation of sentences operating concepts such as "belief", "assertion", "conviction", and the like.) Basically there is no need to raise objections to the conception of the truth value as a denotation of the sentence. It should however be borne in mind that this conception cannot be placed at the same level with the conception of the denotation of individuals and predicates, and that this conception exceeds the framework of the relations between blocks A and C. This practically implies that we are actually moving within this framework at only one of these levels, whereas at other levels, i. e. at the level of statements or sentences, at the level of sentential complexes and the like, we have already exceeded the said framework. It is natural that if we select other schemes of analysis of the universe of discourse, such as the events scheme, we shall witness a change also in the form of that level which remains within the framework of the relations between blocks A and C.

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So far, we have been considering the concept of "level" from the point of view of block C, i. e. from the point of view of the sphere of statements. The concept of level can, however, also be considered from the angle of block A. In this respect, taking into consideration physical and chemical phenomena, we meet with a differentiation of the macrolevel and the microlevel, the macroscopic, quantum and subquantum levels, taking into account economic phenomena, we meet with a differentiation of various economic levels (national level, level involving a branch, an enterprise, etc.). We also witness the differentiation of diverse levels of biological, social and other phenomena. In all these and similar cases the concept of "level" refers to block A or generally to the universe of discourse of cognitive activity. It is also evident that the differentiation of the various levels is based here upon objective differences and more or less objective criteria.

While we emphasise that the differentiation of diverse levels rests on objective differences — such differences exist, e. g., between the quantum processes and the macroprocesses in physics and naturally also between the corresponding descriptions of the two processes—this does not mean

that the concept of "level" has or ought to have an absolute meaning and that it is possible to construct some uniform scale of levels, applicable absolutely to all situations. Attempts to establish such an absolute scale were being made, especially in nineteenth-century science. Such attempts usually aimed at an objective substantiation of the classification of sciences, at a lasting differentiation of the so-called forms of the motion of matter, and so on. (Sometimes we were liable to lose sight of the fact that diverse forms of the motion were termed in keeping with the then existing sciences and the previously known types of their competence. The selection of the names of the sciences was then the starting point for the differentiation of diverse forms of motion, and this differentiation became in turn the starting point for the classification of sciences. It is not difficult to realise that this whole reasoning progresses in a circle, and is actually contingent upon the fund of knowledge within our momentary reach.)

The point of view according to which the distinction of the levels is not absolute also implies that it is not possible to prove the existence of some fundamental, elementary or initial level that would represent a reduction basis for the other levels, i. e. such a level to which all the formations of higher levels could be reduced. This naturally does not mean a negation of the importance of any reduction, and particularly not the negation of any explanatory value of the reduction. Taking for instance such a system of levels as are the molecular, atomic and quantum levels, then it is sufficiently well-known that modern physics operates with explanations of numerous phenomena that appear at a "higher" level, with the aid of those elements and means that can be proved at a "lower" level. The situation is analogous in the relations of biological, biochemical, chemical and physical levels, and the like. At the same time it is however notorious that at a higher level appear some phenomena, properties or processes which cannot be explained by all that is accessible to us from the "lower" level. It is evident that this may be due either to insufficient knowledge of the "lower" level or to the occurrence of some new, qualitatively different phenomena at the higher level [6]. In other words, besides quantitative differences between diverse levels we cannot rule out qualitative differences between them.

From what has been said of the mutual relations of various levels it can be gathered that we postulate a plurality of scales of such levels as well as a relativity of what can — under the given circumstances — be

[6] In this connection, the followers of emergent philosophy speak of the „emergence" of new properties and processes, and hence also of „emergent" properties. They of course not infrequently overlook that such „emergent" properties can stem from our insufficient acquaintance with the „lower" levels, or — as it was customary to express in the physics — from the existence of so-called hidden parameters. This naturally does not imply that we should at all cost and under any circumstances postulate the existence of the so-called hidden parameters, as was the aspiration of a certain school of interpretation of the phenomena of quantum mechanics.

considered as an initial level. Moreover, when defining such a relative initial level we cannot ignore a substantial part played by block *B*, i.e. by the observer's channel, the measuring equipment, or generally speaking the channel of science. It should be noted that any system, however superior, which in the cognitive process has the role of block *B*, i.e. the observer's channel, has always but limited possibilities of discerning objects in block *A*, i.e. is restricted within certain thresholds, has but a limited degree of discerning ability, etc. The concept of "level" in the sense set out above is therefore always relativised also with respect to the properties and possibilities of block *B*. From that angle, every level that we are in a position to distinguish from another, no matter whether "higher" or "lower" level, is linked to a possibility of discerning only a finite number of classes or a finite number of properties attributed to the objects of block *A*. This is where, too, the very foundations of methodological finitism are anchored.

It should yet be elucidated what is meant by a "higher" and a "lower" level. Also this distinction must be relativised with regard to the properties and possibilities of block *B*. What matters is the orbit of the data coming from block *A* which block *B* is capable of discerning. Let us for instance assume that block *B* is able to discern information a_1, a_2, a_3 ... a_n. If we improve the degree of attainable discerning power of block *B* (this actually implies that we shall pass from block *B* to block *B'*), so that in a region (e.g. temporal or spatial region) where only a_1 and a_2 had formerly been discerned, henceforth also a_{11}, a_{12}, a_{13} ... a_{1n} and a_{21}, a_{23} ... a_{2m} will be discerned as well, then we shall have passed from a "higher" to a "lower" level. It is obvious that the elements of the higher level will not always coincide with the sets of elements of the lower level.

From this standpoint any refinement of the discerning ability actually represents a transition from the higher to the lower level, and, conversely, any coarsening of such ability, ordinarily accompanied by an extension of the viewing field, represents a transition from the lower to a higher level. However, in practical thinking of natural historians a different approach to these levels has established itself. It is the approach which does not see the prerequisites for the transition from one level to another in just any change in the properties of capabilities of block *B*, but solely in changes that modify qualitatively the nature as well as the function of block *B*. Of the transition from one level to another the following circumstances are, in particular, characteristic:

(*a*) On transition from one level to another we usually come up against the limits of the possibilities of the equipment of one type. Such limits set to the possibilities of a macroscopic measuring equipment with regard to microprocesses is expressed, for example by the Heisenberg relation.

(*b*) On transition from one level to another the character of the basic

laws governing the phenomena being investigated changes as well. Abiding by the problems of physics, it is clear that the character of the laws of quantum physics differs from the laws of classical mechanics.

(*c*) Upon transition from one level to another the changes also comprise the measuring units or the system of fundamental parameters which characterise the phenomena being investigated.

While the said facts can probably be best demonstrated on the transitions between physical levels, analogous facts are likely to occur in other fields as well. However, not always are these facts so thoroughly respected, as is the case in physics. It is for instance absolutely essential that in the analysis of the economic problems we should have at our disposal different systems of basic parameters if we are concerned with the behaviour of an individual, or the economic problems occurring within the framework of an enterprise, or finally the economic problems within the context of the national economy as a whole.

The communication model of cognitive activity described above also permits us to enhance the accuracy of the interpretation of the concept of "experience". On the basis of the traditional approach, as experience we normally understood the complex of sensorial data, i.e. the data that could be discerned and registered by the human observer. Starting from the communication model described above, operating blocks *A*, *B* and *C* we may point out the following rudimentary deficiencies of the traditional concept of experience:

(*a*) The traditional concept of experience is as a rule considerably static: it confines experience to a complex of ready data. At any rate, also the term of "data", which today we usually understand in the informational sense, i.e. as information, originally implied something ready, something that was "given".

In modern science, however, experience cannot be confined to a certain integrated complex of data qualified in a certain manner, ready in any situation. Experience, as we intuitively comprehend it in present-day science, is rather a process, a succession of certain operations, certain qualified measures, and the like.

(*b*) Another drawback of the traditional approach to the concept of science is in that this approach basically postulates data that could be characterised in a uniform fashion as being valid for all the situations. This practically implies that this traditional approach operates with a single type of block *B*, a block *B* binding for all situations. Hence the attempts to develop an entirely uniform characteristic of experience. It is of course generally known that such attempts at a uniform characteristic of experience, as was e.g. assumed by pragmatism, operationalism or some version of logical empiricism (for example the conception of the so-called protocol-sentences, basis-sentences, *Konstatierungen* and the like), could not be considered adequate in all situations.

(c) The traditional approach to experience identifies experience with a complex of ready data, and this actually means that any data are taken on the output of block *B*. This also means that the measure of relevance of these data is being left out of account. The concept of the relevance of data is of course not given in an abstract way, but is always dependent on a given task or a class of tasks and goals that are connected with the investigation of the tasks. This practically means that it is not just any data that can be registered which are essential to the solution of the task. In medical diagnosing the physician may ascertain a multitude of symptoms in the patient. However, for the purposes of the diagnosis only some of the symptoms are relevant, and the measure of relevance of the various symptoms may differ. The concept of the relevance of data cannot therefore be confined to a semantic concept linked with the given universe of discourse, but also be understood as a pragmatical concept, linked to the goals, demands, requirements or expectations that we relate to the investigation of the task in question.

Scientific knowledge, especially in natural sciences, actually operates with another, much wider and more dynamical concept of "experience".

While the interpretation of the traditional approach to experience is being primarily developed in philosophy, a greater accuracy in the modern approach to experience can be rather encountered in the theory of statistical decision-making or in the theory of games. Assuming that we operate the said blocks *A*, *B* and *C*, then what we are confronted with in the last block is a *decision-making process* that is to evaluate the state prevailing in block *A*. Taken generally, as experience we understand all those steps that lead to imparting greater accuracy to the evaluation and to enhancing the quality of the decision-making. It is beyond doubt that this conception of experience does not think of experience as of a static act, but as of a dynamic process, a succession of certain steps.

This approach to experience can be demonstrated on a simple example of statistic decision-making: Let block *A* be represented by an urn containing a great multitude of black balls and white balls. We are however unable to gain an insight into the urn, and only a limited sample of just a few balls can always be taken out of the urn. Indubitably, every further drawing can only improve the estimate of the originally unknown *a priori* distribution, or render more exact the hypothesis of the source of information. The system in which we can include into the calculation the results of the steps taken in the past (i.e. the previous drawings), may be characterised as an experience system. Such a system presupposes the implementation of individual steps on the strength of the evaluation of the results of the previous steps. Evidently such an approach does not take data as isolated pieces of information, regardless of the tasks in which these data can be put to use, regardless of the aims that are being followed precisely in this investigation. In the traditional con-

ception, experience data therefore represent experience only in so far as they can impart greater accuracy to our evaluations, render more exact the hypotheses serving as grounds for the decision-making, and thus raising the quality of the decisions.

The said example of the experience system can be modified further. It should be noted that in empirical sciences we as a rule do not study only the respective fields that remain invariable, but also processes of the changes. From this viewpoint it is possible to modify the original example of the source of information: Let block *A* be once more represented by an urn with a large multitude of black balls and white balls, the mutual proportion of which we are to estimate. Let us further presume that we cannot gain an insight into the urn, and that we cannot draw but a limited sample comprising just a few balls. However, besides the operation performed by the human observer or experimenter, there is a demon, who can—also in certain intervals and in certain limited numbers—add to the urn or withdraw from it black or white balls, thus somewhat altering the original *a priori* distribution. In such a situation two cases may occur: In the first case it is the demon that "works" faster than the human observer or experimenter, who in such a case has no chance to improve his estimates of the *a priori* distribution. It is known that the familiar Bergson scepticism takes this view of the problem of experience. The development of knowledge in natural history, however, rather bears out the second alternative, in which the human experimenter is faster, prompter and also cleverer than any demon of nature. From this standpoint the experience process is a game against a partner whose strategy we are not familiar with, or which we know only partly, and who is capable of somewhat changing these strategies. However, step by step we are capable of overcoming him. This latter alternative instance corresponds to that approach to scientific discovery which was devised by A. Einstein and N. Wiener.

From the two schematical forms of experience systems it is obvious that experience cannot be confined merely to the data on the output of block *B*, i.e. to the results of the observation, measurements or experiments that have not been evaluated, but must also include the evaluation of the former results of this kind as well as of previous decisions which were selected in view of the results hitherto registered. Consequently, also the concept of experience is not restricted to data on the output of block *B*, but includes any measures leading to an improvement in the quality of the decision-making, for example improvements in the function of block *B*, improvements in the hypotheses on the basis of which decisions are taken, increasing the accuracy of the evaluation of the state or of the changes in block *A*, as well as a more exact formulation of the expectations of possible consequences of the chosen decisions, etc. The factors to which are due the extension and perfection of experience

therefore comprise not only progress in the sense of a quantitative widening of empirical data, but also any advances of theoretical nature or advances achieved in measuring and experimental techniques, which are liable to improve the quality of our decision-making and lend greater accuracy to our knowledge of the universe of discourse under our scrutiny.

REFERENCES

CARNAP Rudolf, *Introduction to Semantics, Studies in Semantics,* Cambridge (Mass.), 1942.

GABOR Dennis, „Theory of Communication", *Journal of the Inst. Elec. Engrs.,* London, S3, 1946, p. 429.

KÖRNER Stephan, *Experience and Theory,* London, Routledge and Kegan Paul, 1966.

WITTGENSTEIN Ludwig, *Tractatus logico philosophicus,* New York 1922.