Definition and Properties of the Concept of Structure as a Methodical Tool in the Sciences of Man

1. Introduction.

Any scholar who is interested in the methodology and philosophy of science cannot but be struck by the high frequency of the term "structure" in the vocabulary of science during the last four decades. And he is likely to ask himself if that key-word of so many sciences studying distinct fields of reality, refers always to the same concept. He would also like to have a clear definition of a generally applicable, abstract concept of "structure", which would leave alone the characteristics of particular objects of research and be restricted to a minimal number of axioms. He would like to know if he has the right to dispose of the concept of "structure" as it is defined in a particular branch of science, in order to apply it somewhere else, in some other branch. If this should be the case the concept of structure would be a methodological tool. In fact it is already used in that way especially in the sciences of man. It would be interesting to see what are the properties of the scientific method which a general concept of structure implies.

Confusion must ensue if a definition of a concept is introduced without reference to the language system in which it is used. So we will make distinctions here between definitions of "structure" in ordinary language and in formal systems. For ordinary language we distinguish the historical point of view from the systematic. We adopt an abstract and therefore most general definition of structure in strictly logical terms and finally we try to give a "real" definition of "structure", based on a comparison of the characteristics of the concept in three branches of science chosen intentionally : moving from a high degree of dependance on the external world ("structure" in perception), through an intermediate degree (language structures), to the lowest degree of dependence possible (abstract) structures in axiomatic systems). This 'real' definition of 'structure' is expressed as a set of properties of the concept.

2. Definitions.

2.1. *From an etymological and historical point of view: "structure" as a theoretical model in natural languages.*

Every concept is dependent on a certain model which the speaker forms of reality. This point is important because the regular extension of a term indicates the success of that particular model of reality which the term denotes. So we want to see what kind of model "structure" indicated originally, in order to determine from the semantic extensions of the term what characteristics remained valuable in its significance throughout the transformations. Those constant characteristics indicate the way in which the speaker saw an increasing part of reality.

The word "structure" derives from Latin "structura", from the root "struo" and indicated the result of a building activity. This original meaning has been dominant for a long time. For instance, in French in the end of the XIXth century we find in Littre (1) about the "néologisme : structurer" "ce verbe est fait avec structure, comme conjecturer avec conjecture, mais il est inutile, car on a construire".

So originally the term "structure" did indicate a model of that part of reality which had been constructed by man himself. The term model is particularly apt here, because in architecture, probably for the first time in the history of mankind, isomorphic representation on paper of a part of reality was produced (2).

The first extension of the term "structure" comes when the ancient grammarians applied the concept to sentence structure. We have a metaphoric use here: the familiarity with the term "structure" as a result of construction activity is utilized in order to describe the characteristics of language in an indirect way. Architectural patterns constitute here a "theoretical model" for language analysis. But we see here that the model undergoes an important transformation owing to this semantic extension: the nature of the objects used is henceforth of no importance. The elements of the "structure" are no longer stones or wood, but have become variables, and "structure" has become an expression of the result of human action, namely, combining, linking together and constituting a whole, on the basis of undetermined elements.

We find another semantic extension when "structure" is used to indicate the human organism. In ancient French: "puisque nous avons si

(1) Littré, E.: *Dictionnaire de la langue française*; Paris, 1870.

(2) This point was suggested to us by prof. E. Vermeersch.

belle proportion en la structure corporelle" (3). In a comparable extension in the 17th century "structure" is applied to the universe (4): "Les planètes s'arrêteront / Les éléments se mêleront / en cette admirable structure / Dont le ciel nous laisse jouir." This semantic extension has once more produced a transformation in the model: the idea of a human builder has disappeared, but a divine builder, a metaphysical principle or nature herself has taken over the role. We can suppose here that a metaphysical belief was the reason why a non-human builder was part of the model. It is also possible that the model, being the only available representation of certain parts of reality made these metaphysical assumptions necessary.

During the XIXth century, the historical dimensions in the human sciences on one side and the application of the transformed model of "structure" to social and political questions on the other, give as a result the concept of structure as it is used by Hegel and Marx. Here the external builder of structures is replaced by "historical forces" which are responsible as anonymous and massive constructors of structures in social, economic and cultural systems.

As empirical method becomes more and more successful in science and as mistrust of anthropomorphic and metaphysical elements in the method or in the results of science increases, the model of "structure" changes again: no longer is an external builder taken into account and "structure" has become an indication of the result of positivist scientific investigations. All branches of science use the structural model after biology, geology and chemistry: as an expression of the spatial ordering of an organisation of parts within the whole, by which the proper nature of species, reliefs, minerals, chemical elements can be determined. Structure is now (5): "the mutual relation of the consistuent parts or elements of a whole as determining its peculiar nature or character". In French it reads thus: "manière dont un ensemble concret, spatial est envisagé dans ses parties, dans son organisation; forme observable et analysable que présentent les éléments d'un objet".

But this is not the final state: the model of "structure" owes its success of the last decades to the fact that the theory of science has changed. In all science there is a mixture of influences of the external world on one

(3) Quoted in: Godefroy, *Dictionnaire de l'ancienne langue française*; Paris, 1898.

(4) Quoted in: Robert, R.: *Dictionnaire alphabétique et analogique de la langue française. Les mots et les associations d'idées.* T. VI, 1964, Paris. The verses are from Theophile, Œuvr. Poét., Ode, P. 209.

(5) *The Oxford English Dictionary*, Oxford, Clarendon Press, 1933; (for French) Robert, R.: *o.c.*

hand and of human contribution on the other. What is new in the conception of science in the xxth century is the conviction that the human contribution is a very important aspect of all knowledge, even where scientific knowledge is concerned. The model of structure proved to be very appropriate to express the fact that science is a human construction. Reality is no longer considered as a field where structures can be taken as a finished product. Certainly it remains true that the model of structure supposes reality to be analysed into its constituent parts. Empirical research is the first step towards the knowledge of the structures of reality. But the difference is that reality is now considered to be "reconstructed" on the basis of that analysis, and it is especially that aspect of "reconstruction" which is very important to all "structuralists" : "La structure, conçue comme un ensemble organisé de rapports, comme un système qui est latent dans l'objet considéré, ou au contraire une partie de l'objet (son noyau)".

This final state of the model of structure with the accent on the reconstruction of reality, a reconstruction which is not necessary an isomorphic reconstruction, but at best an approximation of such an isomorphic representation of reality, shows clearly that henceforth a dividing line exists between the characteristics of the method of description in scientific research on the one side and the characteristics of the objects of that description in reality on the other. The description of reality is a work of construction of the scientist as well in natural as in social and human sciences. This view of his work has been developed by the scientific worker in a rather paradoxical way : trying to be ever more consistent with reality and leaving alone everything that was to be considered external to the objects he wanted to describe, he finally discovered that he was describing his own description.

Now the cycle of historical evolution of the theoretical model of "structure" is round : starting from his own activity (building, speaking) man thinks during a number of centuries that it can be a model for the whole reality and that he has the right to recognize himself everywhere in that reality, until the moment he discovers that what he recognizes everywhere is just what he continually adds to that reality, namely the way he reconstructs the world around him in the terms that he had chosen. Now "structure" has become a way of description and it can be studied in turn : the means has become the object of research (6). Reality is henceforth something else and the scientists main preoccupation in the future will be to determine,

(6) The means becomes the goal of research. This idea has been developed by prof. L. Apostel (see 19).

over and over again, if the reconstructions he has given of reality are the best ones which reality deserves.

DEF. I : The term "structure" (diachronic scheme for natural languages) = df.

a theoretical model starting from descriptions of products of human activities, ranging over the whole scope of reality and finally indicating the way in which human thinking is reconstructing reality.

2.2. *A general definition of describing : structure in terms of modern logic.*

With respect to the above definitions in natural languages, there are two points to be observed : (a) they are intensional definitions, as opposed to extensional ones, i.e. there is no reference to special parts of reality as would be the case in enumerations of all other kinds of structure (algebraic structures, physico-chemical structures, social structures etc.). This is an important point because many colloquia (e. g. (7) and (8)) succeed only in giving an idea of a great number of very different "structures" without any visible relation among them. We would say that those contributions give extensional definitions of structure because they indicate to what kind of objects in reality the term "structure" may be applied. Only the intensional definitions are interesting for us if we want to find some unity among the apparent diversity of "structures" with which we are confronted. (b) the intensional definitions owe their general character to the fact that in a systematic way all constant factors have been eliminated from the definition : they have all been replaced by variables. The intensional definitions speak about "wholes" and under influence of modern pure mathematics about "ensembles". These terms indicate a class whose intension is reduced to the act of classification itself and whose extension can therefore reach every object of human knowledge. These definitions speak also about "relations"and we have another variable because it is not stated whether we have operations, transformations or differentiations, nor if those relations are defined in time, in space, or if they are feelings, or whatever they may be. So here again we have a variable in terms of which all observations of our knowledge can be described in a general and abstract way. If we adopt the point of view — and we don't

(7) Bastide, R. e.a.: *Sens et usages du terme structure, dans les sciences humaines et sociales*; Mouton, La Haye, 1962.

(8) *Notion de structure et structure de la connaissance.* XX^e semaine de synthèse. Albin Michel, Paris, 1957.

see any alternative — that our knowledge, and more specifically our scientific knowledge, consists in stating verification and application of relations, then these intensional definitions of "structure" are sufficiently general to range over the whole scope of our scientific knowledge and it is interesting to see how these rather intuitive definitions of structure in natural languages can be expressed in a more explicit and unequivocal way.

On this point we find an important contribution in Carnap's "Der logische Aufbau der Welt" where there is, as early as 1928 a clear consciousness of the necessity of a description of "description in science". The "Aufbau" constitutes an important moment in the philosophy of science and more especially of the philosophy of structuralism because it clearly and explicitly formulated the principles which at that very moment the specialists in many disciplines were trying to apply. Carnap did not create the structuralism but he expressed in close contact with the scientific research of those days the unitary point of view which many scientists would lose sight of at a later date. He was convinced that "die Wissenschaft nur die Struktureigenschaften der Gegenstände behandelt" and concluded thus "dass wissenschaftliche Aussagen von blossen Formen sprechen, ohne zu sagen, was die Glieder und die Beziehungen dieser Formen sind" (9). Of course Carnap had been influenced by the "Principia" of Whitehead and Russell where mathematical branches had been derived from logic in a rigorous way. In linguistics de Saussure had already formulated that language is nothing but "form" (10).

The "Aufbau" presents other aspects which do not concern us here. We will here try only to give a definition of structure in logical terms, which has the mean characteristics of that of Carnap, and of the "relation-number" defined by Russell (11).

It will be useful to describe some shades of meaning in order to give the concept a somewhat easier application in empirical sciences.

"Structure" indicates a new method of classification, if we compare it with a classification where objects are put together in view of their proper nature. When we say that two objects are identical (a = b) we have a criterion of classification which is much more difficult to satisfy, than the criterion of isomorphism which is the basis of the classification from the

(9) Carnap. R.: *Der logische Aufbau der Welt.* 1928. Herausg. Felix Meiner, Hamburg, 1961.

(10) De Saussure, F.: *Cours de linguistique générale*; Paris, Payot, 1916.

(11) Russell, B.: *Introduction to Mathematical Philosophy.* London, 1919.

structural point of view. In the first criterion we speak not only about the properties of two objects or only about their relations, but the elements from which the objects are composed must also be "the same" as well. Not to mention the fact that two different things can be "identical" only by definition, that the "same object" is not necessarily "identical" with itself at every moment, that "identical" must receive some operational definition stipulating its equivalence with substitution possibility, etc. Now these difficulties can easily be avoided if we take "isomorphism" as a criterion for classification : the advantages are clearly (a) the same object can have different structures at several moments and in different situations ; (b) we can distinguish between internal structure and external structure; (c) different things can have the same structure : even between two objects which are of apparently different nature (like dance and music, behavior and thinking etc.) an equivalence relation in isomorphism is possible.

This new kind of classification is a logical consequence of the transformations of the model of structure in a historical dimension, but what language had elaborated in an intuitive and non explicit way was clearly formulated for the first time by Russell : "cette structure ne dépend nullement de la nature particulière des termes formant le champ de la relation (..) Deux relations ont la même structure, dirons-nous, lorsque la même représentation de l'une représente l'autre (..) quand elles possèdent le même nombre-relation" (12). The concept of isomorphism has become central in modern logic and mathematics (13). What is called in Russell a "représentation", and in Carnap (14) a "Pfeilfigur" is an easy intuitive model indicating two classes on a diagram, where a necessary limited number of points indicate the elements in each class and a number of lines between these points, represents the relation between these elements. Isomorphism as a criterion is here intuitively satisfied if the distribution of the lines is in the two classes the same : "Haben zwei Beziehungen nun dieselbe Pfeilfigur, so heissen sie "von gleicher Struktur" oder "isomorph". Die Pfeilfigur ist gewissermassen die symbolische Darstellung der Struktur".

For a general definition of isomorphism in more formal terms we need set-theoretical or logical terms as "class", "relation", "elements" and "one-one mapping" :

(12) Russell, B.: *o.c.*, traduction française de G. Moreau, 1952.

(13) Voir p.e. Bourbaki, N.: *Éléments de mathématiques.* Livre I: Theorie des ensembles; Paris, 1957.

(14) Carnap, R.: *o.c.*

DEF. II: Two objects A and B are "isomorphic" = df. if the following conditions are satisfied:

(a) A and B can be described as non-empty classes A' and B' each with a finite or infinite number of distinguishable elements:

$\{a_1, a_2, \ldots a_n\}$ and $\{b_1, b_2, \ldots b_n\}$

On A' and B' a finite number of relations can be described, where two relations are different if their number of arguments is different (binary, ternary relations etc.):

$R1_{A'}$, $R2_{A'}$, ...$Rn_{A'}$ and $S1_{B'}$, $S2_{B'}$, ... $Sn_{B'}$

(b) A one-one mapping F of the elements of A' on those of B' can be effectuated in such a way that:

$(\forall a_i \in A')\ (\forall b_j \in B')\ [(a_i, b_j) \in F_{A' \times B'}]$

(c) one-one mappings are possible between the classes of couples, tripels etc. ordered in the relations on A' and those ordered in function of the relations on B'; this means that the number of relations must be equal in A' and B' and that the mapping F (described in b) can be effectuated in such a way that each time that a certain relation exists between two or more relations in A', the same kind of relation must exist between the corresponding elements in B'.

$$(\forall a_i, a_j \in A')\ (\exists b_i, b_j \in B')\ [(a_i, b_i) \in F_{A' \times B'} \wedge (a_j, b_j) \in F_{A' \times B'} \wedge (a_i, a_j) \in R_{k\,A'} \rightarrow (b_i, b_j) \in S_{k\,B'}]$$

Now it is clear that our definition of isomorphism is rather idealistic. In practical science the first condition is often forgotten, which means that the distinction between objects or fields of reality and the description on the basis of which isomorphism can be established is often omitted. In fact the only branch of science where such a distinction is superfluous is pure mathematics and logic. Because there we have a description which constitutes its own object, we have description in its pure form and therefore structures in their pure form too.

The second condition is perhaps not omitted, but its importance in practical scientific research is certainly inferior to that of the last condition. What is important for structure is first of all the relations, and therefore elements are a necessary condition. But we can imagine for instance in social sciences that one element can be used for different structural functions or that it has no function at all, so in a weaker conception of isomorphism we can often consider the second condition as being approximative for isomorphism.

We can imagine, as well with our weaker as with our strong criterion that two objects in reality have been studied and described and that they are found to be isomorphic. Now there are several possibilities :

(a) after some time new relations are discovered in one of the objects or in the two : they may be no longer isomorphic.

(b) some time before isomorphism was discovered there lacked only a few links : isomorphism was probable, but not attested.

(c) only a part of the aspects of the objects have been studied : there is isomorphism, but what is the value of this result?

What we see here evidently is that our clear concept of isomorphism looses a part of its clarity as soon as it is confronted with the always changing results of the description of reality. Anyway we can formulate the more relative concept of approximative isomorphism and have a criterion for ordering the degrees of isomorphism. Therefore we consider the degree of isomorphism as a function of (a) the internal order between the relations ; and (b) the ratio between the stated number of functional elements on a certain level and the number of elements described in isomorphic relations. Of course these points of reference are not absolute, can equally change in time and presuppose already a certain model of the objects we study, but there is no vicious circle and the result of the valuing of the relative isomorphism can continually be improved.

Let us first make clear what we mean by "internal order" between relations, by considering an exemple from Goodman ([15]) : ((a,b,),c), (d,e) The sequence here is a couple, a binary relation with the components ((a,b,)c) and (d,e). The components can in turn be dissolved, until we get what Goodman calls "ultimate factors". It is clear that the binary relation which the sequence presents is itself a relation between relations. This case can be generalized so that we have different levels, where the first level is the sequence as a whole. Dissolving step by step we find the following levels. Now the degree of isomorphism is function of the order of the level where isomorphism or approximative isomorphism has been established : higher levels involve a higher degree of isomorphism.

With the ratio between the stated number of functional elements on a certain level of two objects and the stated number of elements explained in function of isomorphic relations, we introduce a quantitative aspect. The question of the degree of isomorphism depends on the question of how much has been explained of the objects under description : the value of our isomorphism depends on this aspect too.

(15) Goodman, N.: *The Structure of Appearance*; Harvard Univ. Press, Cambridge, Massachusetts, 1951.

After having described a general concept of isomorphism, the general concept of "structure" can be easily defined:

DEF. III: "structure" (general definition scheme) = df. the class of all classes between which the composed equivalence relation of isomorphism holds to a certain degree.

DEF. IV: "pure structure" (only present in pure mathematics and logic, where description and object coincide) = df. the class of all isomorphic classes.

2.3. *Application of the concept of structure to formal systems.*

In formal systems the properties of the concepts used are much easier to determine than in any other language system, because these properties have been formulated explicitly in the premises of the system. Those premises are indicated here in the form of postulates and consequently they have been determined entirely in the sense we wanted to attribute to the concepts: the properties of any term used in the language of formal systems are internally determined by the system itself.

So we can ask: what would be the place and the properties of the concept of structure in such a formal system? What is true for every concept in general in formal systems must be true for this concept too. In fact we see quickly that the whole term of "structure" is not a permitted combination of signs in formal systems. So "structure" is here a metatheoretical concept. We find back here our general definition for structure, more specifically the definition for "pure structure", because structure indicates a class of conditions: these conditions determine in fact the distribution of the relations on the set of permitted combinations of signs. But as the relations are the result of a number of operations effectuated on the primitive terms, which are not defined and which have therefore no properties by themselves and are irrelevant to the structure of the system, the structure indicates in fact the conditions imposed on the operations to be effectuated in the system.

DEF. V: "structure" (metatheoretic concept for formal systems) = df. the class of all classes of conditions defined on operations.

This definition of "structure" is in fact only an adaptation of the former definition to the language system we use now: the conditions imposed on the operations determine unequivocally the distribution of the relations and fix in that way a class of isomorphic classes. It is important to see that only the language system has changed and that the definitions are equivalent.

So "structure" is a class here composed of "rings", "groups", "monoids" etc. each of these terms indicating a number of properties of a number of operations. It is clear that the total number of formal structures does augment in two ways: (a) when a new operation, determined by a new set of conditions, or even by one single new condition is defined; (b) the new combinations of already known properties of conditions imposed on the operations. Evidently, we are reaching here, along with the concept of structure, the proper field of creation of pure mathematical and logical thinking: it is impossible to give an enumeration of all possible abstract structures. Their number may be theoretically infinite, although practically the number of known abstract structures is limited by two factors: (a) the lack of time necessary to check all the possible combinations of properties of operations, or all the combinations of different operations with their possible properties; (b) the human being has a limited power to grasp high degrees of complexity, with the result that he is not only incapable of checking, but even of understanding and of applying certain highly complex systems. Now we can imagine that for (a) the progressive application of electronic machines would enable us to move the borderline so that more abstract structures become available in a relative short time. For the second point (b), it is doubtful if the limited capacity of assimilation of information can change. So in the future it is very possible that we will have more and more abstract structures available, of ever growing complexity, and that we will have largely transgressed the borderlines of applicability. This perspective of a practically inexhaustable arsenal of abstract structures contrasts of course with the assertion sometimes heard, that the language of abstract structures would be so narrow and bounded, that for a certain number of scientific disciplines, especially sciences of man, an application to empirical problems would be impossible.

2.4. *Impossibility of a univocal analytic definition in natural languages.*

Until now we have continued to maintain a unitary definition of structure, adapted always to the language system in which it was expressed. Can this unitary view be preserved if we try to find an analytic definition in synchronic natural language systems? The problem is not superfluous, because much literature about the subject "what is structure" takes just this approach. We take for instance Matoré ([16]) "le mot (structure), employé souvent par des gens qui en ignorent la signification exacte, demanderait à être défini de manière précise, or une telle tâche est impossible,

(16) Matoré, G.: *L'espace humain*; Paris, 1962.

car l'expression se teinte d'acceptions très diverses, non seulement suivant les milieux qui l'emploient, mais aussi à l'intérieur d'une même discipline..."

Now we ask first : what is an analytic definition of a concept in general? The general problem has been treated in a very clear way by Hempel ([17]) and perhaps it is useful to recall his findings here when we are confronted with the concept of structure.

An analytic definition of a term is any definition which states the way in which a term can be used in a language system. For natural languages the use of a term can be defined by indicating what words or combinations of words can be substituted for the definiendum, in such a way that the meaning of the defined word in that language system has not been changed. The familiar example of a collection of such analytic definitions is the dictionary. We can here even trace a borderline for linguistics in respect of this definition : every time that a dictionary refers to some field of reality, it is no longer a dictionary, but an encyclopedia.

If we try now to find a univocal analytic definition, we arrive quickly at the conclusion of Matoré : such an univocal definition of "structure" is not possible in a natural language system. But this is not due to the particular characteristics of the concept of structure ! It is inherent in the characteristics of the natural language system itself. This does not mean that there are no definitions for structure here : there are too many of them. That is what many people establish again and again.

But what is the cause of this situation? The meaning analysis or analytic definition presuppose (a) determinacy of the conditions under which a term is used ; (b) uniformity of these conditions for all language users : neither of these two presuppositions are fulfilled for natural languages of course. Only the closed systems of formal theories fulfill them. The language of scientific research, taken as a whole, forms a department of these natural languages, although in certain fields formal systems may be used as formal models. The language of science, where the concept of structure is used, is just as much as any natural language an open system which means according to Apostel ([18]) a continual adaptation of that language system to the distortions caused by the results of the empirical study of reality on the one hand and by the changing goals of scientific research on the other. The open system of the language of science as a whole undergoes continual changes and differentiations, which means that the rigourous

(17) Hempel, C.: *Fundamentals of Concept Formation in Empirical Science. Intern. Encycl. of Unif. Science*, vol. II, n° 7, Chicago, 1952.

(18) Apostel, L.: *Theory and History of Scientific Thought.* Course delivered at the University of Ghent (unpublished).

presuppositions as determinacy and uniformity of usage cannot be fulfilled when this system is used as a medium for communication.

The meaning of a concept like structure in the natural language of science as a whole is variable in ressort of the characteristics of reality. We shall treat this important aspect in the next section. We just want to indicate the other disturbing factor as to the meaning of a concept: the changing goals of scientific research. We find in Ackoff ([19]) an interesting illustration of this variability of the meaning of a word in respect of the goals of research as he analyses the intuitive definition which scientific investigators hold for such an apparently problemless term as "room". Now we could ask of course what are the goals of the scientist when he uses the concept of structure? Are they classifiable? Do these goals correspond to specific human needs which he expresses in the way he wants to describe his world? Such questions will be treated in another study which we prepare as an outline of the structuring human being. For the present paper these questions determine the way in which the "real" properties of "structure" as a methodical concept have been classified and presented from a general anthropological point of view.

3. Properties of the concept of structure in the sciences of man.

We now no longer ask for the meaning analysis of a word, but we want to know, in accordance with the principles of "real definition" in Hempel ([20]) what are the essential characteristics of those parts of reality to which the term "structure" is applied. These "essential characteristics" are to be the necessary and sufficient conditions to apply the term "structure" and in that way they give us an intensional description of the concept of structure when that concept is applied to reality. So the method to arrive at our real definition of "structure" is like this: we know what objects or what fields of reality are referred to by the term "structure". The extension of the term is known, as is proved by the fact that the term is frequently used in ordinary and scientific language. Now we study in a certain number of scientific disciplines in what way structure has actually been described there. It is interesting to remark here that we do not study reality itself, but the studies of reality: we move at a metascientific level. The reason for this method is clear from our definitions and especially from our definition of "isomorphism", where we explicitly establish that structure is a class of descriptions and not a class of

(19) Ackoff, R.: *Scientific Method. Optimizing Applied Research Decisions.* New York, London, Wiley, 1962, chapter V: Defining.

(20) Hempel, C.: *o.c.*

objects in reality. If we want to know the influence of reality on structure, we do not study reality, but the "structures" which are the result of a confrontation with reality.

For the human sciences the problem is a little more complicated, because "reality" means there in fact the human behavior taken in a wide sense. But behavior is itself already a reaction to an environment and so to "reality". Now, to be clear, we mean always with "reality" : the object which a certain scientific discipline studies, that about which the objective language of a science speaks. This means for pure mathematics and logic that "reality" coincides with the description itself. It may be that there is an isomorphism to a certain degree between the structure of science and the structure of human behavior which is studied by that science.

So now we will make an interdisciplinary comparison between three branches of the human sciences in order to establish what are the necessary conditions to speak about "structure" there, or in other words, to determine what are the properties of "structures" described in empirical sciences. We supposed a graduation between (a) structures of perception, where the human organism seems to elaborate his structures in narrow contact with the external world and is therefore the less free to order the materials with which he constructs his aggregates of perception. If the human being under these conditions is able to establish a certain ordering, we must conclude that we have a very strong tendency, which will manifest itself even more easily in (b) structures in language. There man has liberated himself to a greater extent from the pressions of the exterior world. Finally we compare with abstract structures in pure mathematics and logic, because there are no longer disturbing influences from the exterior world here and the tendency to structuring can be realized with a maximum of result.

For perception structures we consider the work of Allport ([21]) as very important and we will start our comparison on the basis of the properties he analyzed in the different theories of perception which have been formulated from the beginning of the scientific study of perception. These properties include, for instance, those expressed in Gestalt theory. We will indicate further to what extent these properties of structures in perception are also present in the compared disciplines and on the basis of induction we postulate that these properties of structures are general properties of structures in all human sciences : in this way we arrive at a "real definition" for the concept of structure in the human sciences.

(21) Allport, F.: *Theories of Perception and the Concept of Structure*; London, 1955.

3.1. *Tendency to interrelatedness between elements and subsystems in every structure.*

The elements which constitute the aggregate of perception are all interrelated and are mutually dependent. Aggregates, or perceived wholes, can in turn be related to other subsystems within a greater system of a perceived field of the world. The subsystems can be placed side by side, or there may be a relation of inclusions between them, so that there are higher and lower orders: an element in one structure is itself a structured composition of other elements at a lower level; and the converse relation also holds of course.

We can state here that we have really a "structural" property of perception aggregates, which means that we have the result of a human activity which is transcendent to what the exterior world offers: the field of mutual dependence and influence in which events of perception are combined exists only for an organism, and in an organism only to the degree in which the external world presents an occasion to apply a synthetizing activity.

If we compare now with the structure of a natural language system, we see that the interrelatedness of linguistic signs and combinations of signs is one of the basic "dogmas" of structuralism in linguistics. Especially de Saussure ([22]) expressed this feature of language structure: "Il n'y a pas de changement phonétique isolé (..) L'ensemble des articulations d'une langue constitue en effet un système où tout se tient, où tout est dans une étroite dépendance. Il en résulte que si une modification se produit dans une partie du système, il y a des chances pour que tout l'ensemble du système en soit atteint, car il est nécessaire qu'il reste cohérent".

As an explanation for the fact that interrelatedness is present in linguistic structures as well as in perceptive aggregates, we could advance that language is to a large extent based on perception. Generally speaking, the fact that a human being constitutes a great deal of his structures with the help of perception could be an explanation of the fact that interrelatedness is present in structures other than the perceptive ones. But a stronger explanation is provided by the hypothesis that perception is itself a form of action of an organism, that language structure is another one and that it is precisely that action of the organism which has the property to connect every element or system (objects, perceptive events, linguistic signs, etc.) into a unity which is the universe in which the actions

(22) De Saussure, F.: *o.c.* p. 167.

of that organism develop. This universe corresponds to the "Umwelt" of Von Uexküll ([23]).

But here we see also some differences between the perceptual and the linguistic structures which are so important that it is probably the reason for the prevalence of linguistic structures above perceptive ones in all human cultures: (a) the arbitrary character of the linguistic sign, in the sense that there is no necessary relation between the linguistic signs and the characteristics of objects and situations to which they are supposed to refer. This aspect has created a liberty in the choice of terms only restricted by the linguistic traditions and the internal necessities of the linguistic system itself (sufficient distinctive features, morphological rules etc.) This liberty contrasts with the boundedness and the "given" character of perceptual events; (b) transcendence over the observable world by the introduction of semantic values based on convention, implicit definition, classifications, extensions of meanings which were based primitively on observations: words such as "goodness", "hypothesis" and "negative" have enlarged the human universe and contributed to the creation of a "new world" in which the observable world is present as well as a nonobservable one. And in fact the human being needs two worlds between which he can oscillate in a cybernizing activity of continual transformation of the world; (c) the virtual character of the linguistic signs, the basis of the distinction of "langue" (in contrast to "parole") made by de Saussure which means that every linguistic unity can be produced at any moment by any language user. It is clear that such a possibility of actualization of the elements which the language user needs for this structuring activity at any moment and at any place is exactly what is lacking in the constituent elements of perceptual structures.

The difference between perceptual structures and structures in language results practically in the fact that in his language system the human being creates a new world which he dominates better and where he can describe relations between wider variable elements and systems, without being strictly bounded by the factual restrictions of a given external world.

If we compare now these results with "pure structures" in formal axiomatic theories, we find that the interrelatedness of all elements in the theories is here even more explicitly expressed than in perception and in linguistics. Axiomatization is in fact nothing else but the elimination of everything from the system which has no explicit relations with the other elements in the system. It may be decided in a finite number of steps if a given combination of symbols is permitted in the theory, that

(23) Von Uexkuell, J.: *Theoretische Biologie*, 1928.

is to say if the combination has been derived from the primitive terms in accordance with the formation rules that have been defined. And it may equally be decided in a finite number of steps if a certain formula, expressed in terms of these permitted combinations follows from the postulates which have been explicitly defined in the theory. The logical rules which are used in the proofs have found an explicit definition in the same theory.

Here, in pure mathematics, there are relations between subsystems as a result of the "axiomatic research", which is the proper name of the structuralism in mathematical sciences and in modern logic. After the work of Peano, Russell, Whitehead and Hilbert we have now the more recent results of a French group working under the pseudonym of Bourbaki (24). The relations between subsystems become clear only when the subsystems itself have already been described. The structure of the whole architecture of a unitary mathematical system is discernable as a result of axiomatics: "L'évolution interne de la science mathématique a, malgré les apparences, resserré plus que jamais l'unité de ses diverses parties, et y a créé une sorte de noyau central plus cohérent qu'il n'a jamais été. L'essentiel de cette évolution a consisté en une systématisation des relations existant entre les diverses théories mathématiques et se résume en une tendance qui est généralement connue sous le nom de "méthode axiomatique" (25).

But although the property of interrelatedness proves to be present in formal axiomatic theories as well as in language structures and in perceptive aggregates, there are differences to note here again. From the point of view of interrelatedness there are no more elaborate structures than those of formal systems: while in perception the establishing of relations was still dependent upon the factual presentation of data and while in natural language systems the reference to objects and situations was still necessary to establish relations in an univocal way, these restrictions are no longer present in the abstract systems of formalized axiomatic theories. The relations determine the whole system and the relations alone. And as it is just the relations which constitute the system, we have here the structure in its pure form. So we can say that perceptive structures and structures in language are efforts of man to realize a structuralizing tendency on the basis of the means at his disposal. Linguistic signs already permit him to arrive at better results than direct confron-

(24) Bourbaki, N.: *Éléments des mathématiques*; Paris, Hermann (paru en fascicules).

(25) Bourbaki, N.: *L'architecture des mathématiques*; in: F. Le Lionnais (Ed.): *Les grands courants de la pensée mathématique*; Paris 1962 (2e ed.)

tation with the external world. In linguistic behavior the human being is more free to build systems of relations. But only in formal systems can he show what kind of being he really is: a constructor who is always in search of unity in a universe he constructs himself.

If we generalize this first property of structures to all human sciences we must note that there will certainly be a time dimension, a genetic aspect of this interrelatedness: we can imagine that in a primitive stage of structuring not all the interrelations have been established. This aspect can explain that a certain object of perception keeps holding the attention as long as all possible interrelations have not been established. And on the other hand it can explain the fact that an object no longer holds the attention when this activity has been performed and has been recorded in the memory as a final result.

If we suppose that the structuring activity holds good even for the arts—and we don't see how it could be otherwise—then our first structural principle would also explain the fact that the evolution of art starts from rather amorphous or chaotic forms, arrives in a classical period at clearly delineated forms, which are generally characterized by rather simple basic patterns, and finally arrives at a kind of rococo elaboration after which the whole pattern is abandoned and replaced by quite different structures. Clearly the desire to establish clearer and gradually more interrelations is apparent in such an evolution.

The cyclic evolutions in economic systems, where crises are present after regular periods can probably also be explained in a structural way if we consider social and economic systems in their tendency to arrive at saturation. Modern planning would consist here in a continual creation of new structural patterns which all have a different saturation moment. It is a rational distribution of the saturation moments of the different structural systems which can prevent general socio-economical periods of crisis.

We consider this first property of structures as present in every science of man and this is of course a methodological hypothesis which can only be confirmed by the results of factual scientific research itself.

3.2. *Tendency to closedness in every structure.*

Perceptual aggregates appear to be definitively determined wholes, notwithstanding their complexity. They may be extended in space as well as in time and eventually as well in space as in time, but the borders are never indefinite. The closedness, or better, the self-closedness of the perceptual aggregates constitutes a necessary condition for the interrelatedness to be effected: interrelatedness would not be possible in an open

system. But there are degrees of closedness as there are degrees of interrelation.

So perceptual structures tend to close themselves in time and space, which means that the elements that cannot be integrated in the perceptual aggregate are not perceived. According to Apostel ([26]) we have here the most striking paradox of perception : in fact there is not only the closedness in time and space, but within the unit of space and time where the perceptual aggregate is situated there is a continual selection and inverse operation which destroys the immediately constructed wholes with reference to a system of classification which preexists and if possible is maintained as a model of reality which will be changed as little as possible. Although perception is evidently a way of entering into contact with the external world and of getting information about that external world, perception is organized in such a way that the new information is as reduced as the equilibrium of the organism in its environment can tolerate.

It is clear that the closedness of perceptual structures has an important bearing on the epistemological status of perception in philosophy of science: a conception of pure empiricism is not made legitimate by the relative closed character of perceptive structures. The importance of models and theories in scientific research and their bearing on what will be "facts" and what not, is related to this problem into which we cannot enter now.

If we compare the closed character of perceptive structures with natural language systems, we find again that this structural property is of very great importance. Here de Saussure ([27]) is once more the precursor and it is interesting to see that he had to formulate in an explicit way that he was choosing deliberately a new methodical orientation : in order to describe language as a closed system, it is first necessary that we should want to consider language from that point of view : "Bien loin que l'objet précède le point de vue, on dirait que c'est le point de vue qui crée l'objet". Just as in perception theories where the theory of the "Gestalt" had as its primary merit to have focused attention to the regularities in perception and the relatively closed character in respect to new information, so the linguistic structuralists, to begin with the methodical orientation of de Saussure studied the regularities and constant relationships which became evident only when language was studied apart from the openness to non-linguistic aspects of behavior and reality. "Si nous étudions le langage par plusieurs côtés à la fois, l'objet de la linguistique nous

(26) Apostel, L.: *o.c.*
(27) De Saussure, F.: *o.c.*

apparaît un amas confus de choses hétéroclites sans lien entre elles (...) il faut se placer de prime abord sur le terrain de la langue et la prendre pour norme de toutes les autres manifestation du langage." Language must be studied in itself and for itself. The same methodic attitude is formulated by Hjelmslev ([28]) when he postulates a description of language as "une entité autonome de dépendances internes, ou en un mot, une structure." But the explicit application of these methodic principles, based on the closed aspect of linguistic structures is to be found in the work of Chomsky ([29]), following the basic attitude of Harris ([30]) and his descriptions of "distributive" structures in language : language can be described without any reference to semantic aspects of language, which means in fact that these American linguists considered the language system as totally internally determined, or, formulated in our terminology, as a closed system.

Now it is evident that language is not a totally closed system and Chomsky, Katz and Fodor ([31]) and others have shaded their attitude. In our opinion however and from a methodic point of view the concept of a closed language system is not only justified, but even necessary. If we formulate it in a strong way : language can only be studied to the extent to which the structures are closed. If there is no closure there is not yet structure. And this is the whole reason why structural semantics has until now proved to be so little successful : The openness to the "world" is per definition undetermined and finally semantic studies risk resulting in descriptions of the world, which is of course to exceed the scope of linguistics. It is easy anyhow to give a criterion for a borderline between linguistics and description of the world : only those aspects of semantics are relevant to linguistic studies for which linguistic forms offer a sufficient basis for distinction. It is just the discrepancy between the available formal distinctions in a given language system at a certain moment on one hand and the personally elaborated views of the world of language users on the other which is to a large extent responsable for evolutions in natural language. Linguistics must stay in the domain of formal distinction, which means that for the linguist language systems are closed as soon as he starts studying them.

(28) Hjelmslev, L.: *Essays linguistiques. Travaux du cercle linguistique de Copenhague*, n° XII, Copenhague, 1959.

(29) Chomsky, N.: *Syntactic Structures*; The Hague, 1957.

(30) Harris, Z.: *Structural Linguistics*; Chicago, 1960.

(31) Fodor, J. A. & Kats, J. J.: The Structure of a Semantic Theory; in: *Language*, 39, pp. 170-210, 1963.

It is interesting to see that the structural property of closedness for natural language systems has been realized with important new methodological orientations as a result. And we see here how the model of the objects which are studied determines the way in which these objects will be approached. But it is also interesting to note that the closed character of natural language systems was found in application long before it was explicitly formulated in methodology: literature is in fact an application of the property of closedness of language structures, because this property is a necessary condition to make the fictive world possible: phantasy is not "a characteristic of man", but it is a characteristic of the medium which constitutes language that it is a closed medium. And this closedness is a sufficient condition for fiction and phantasy.

Let us now turn to the abstract structures of formal axiomatics in order to see if here again the property of closedness is present. And in fact, the bulk of the methodological problems which were to be solved before axiomatics could have its modern results were centered on the property of closedness of the theories in pure mathematics.

The closedness of abstract axiomatic structures is illustrated by the fact that any formal theorem can be called valuable only within a certain theory. The closed character of axiomatic theories is obtained by a new methodic orientation which started with the elaboration of non-euclidian geometrics by Bolyai, Lobatschevsky and Riemann and the discovery of algebraic structures De Morgan, Hamilton and Grassmann. Before these innovations geometry was considered to owe its validity to its fundamental conformity to the characteristics of the universe and algebra was considered as a symbolized form of arithmetics. The new developments established the conviction that there was more than one possible geometry and that a consistent algebra could be constructed differing from the algebra of arithmetic, where for instance the commutative law of multiplication would not hold ($a + b = b + a$). It is clear that this new development is possible because the closedness of mathematic systems is realized and the converse is certainly also true.

But a formal mathematical system is the result not only of a set of postulates, which have replaced the categoric asssertations in the form of axioms that were necessarily true. There is also the interplay with logic which constitutes the rules by which a postulational set can be expanded into a body of theorems. Only during the xxth century was it realized that logic is not a set of fixed, absolute and immutable rules, but that several logics are possible. Lukasiewicz, Post, Tarski and Reichenbach have developed two-valued logic to three-valued, m-valued and infinite-valued logics. Heyting developed a logic where the law of excluded middle was

no longer universally accepted. These are but a few examples. All these "non-Aristotelian" logics have led to the same attitude versus logic as that adopted for the sets of postulates: the logical principles are defined within the system itself and anyone who accepts operation within the system in accordance with the explicitly formulated logical principles will arrive at the same conclusions. According to Carnap: there are no moral principles in logic, anyone can build his own logic but he must clearly formulate his principles and follow them rigorously. We have here another aspect of the closed character of formal structures: even the logical rules are internally determined.

From the preceding comparisons it is clear that closedness is a property of the three kinds of structures we have examined. We conclude inductively with the hypothesis that this property will be present in all structures in human sciences, and consequently will imply everywhere the methodic necessity to describe the structures as objects which constitute closed systems. In the scientific study of literature, to take one example, this necessity has been admitted only recently and not by every scholar in fact. The text of literary works must be studied for itself and this is not only a sufficient approach, but the only one which does recognize the autonomy of a work of art.

Some typical examples of the human tendency to close the structures he has created are the appearance of frontiers or borderlines, even where they are not necessary: the limits of the world in the ancient cultures and even in recent times the supposed boundaries of the universe. In social respects there are initiation rites and ceremonies in religious and ethnological communities and conversely the reputation of elements which do not function properly in the structure. But not only in primitive civilization will the property of closedness be found: ideological groups, student organizations as they were found during a long time for instance in Holland, and irrational movements such as nazism in Germany during more than a decade, racism in certain parts of the world, nationalisms all these social and political structures have as a primary property the selfclosedness, even if the structuring is very poor in other respects.

3.3. *Tendency to permanency: elimination of irreversible time.*

Perceptual aggregates are built along the dimensions of space as well as along the dimension of time. Space and time are equivalent and interchangeable. The distribution of the events of which the aggregate is composed must be thought of as a volume in space and time.

Time is present in the perceptual structures as a fourth dimension and different from time as an irreversible development. Time has an accumu-

lating working which means that the field of perception has been extended with one more dimension and that in the activity of structuring the perception, all events are to be considered as synchronized. The reversible character of time here explains also the learning capacity, the genetic aspect of structuring which makes it possible that the accumulation of events tends to complete the structure and does not continually change what has already been constructed.

In linguistics this aspect of a synchronizing time in language structure has again caused a new methodic orientation which has been clearly formulated by de Saussure as the necessity to distinguish between synchronic and diachronic linguistics. The "structural method" (in fact de Saussure never used the term "structure" or "structural" in this sense, he was a structuralist "avant la lettre") must study the synchronic language system: only those elements are parts of linguistic structure which exist simultaneously in the linguistic consciousness of the language users, and constitute in this way together "un état de langue". Although the language systems change considerably in the long run for a certain generation these changes are to be neglected and all attention is to be given to those aspects which remain unchanged during such a period.

It is remarkable that the structural system of language resists to such an important extent the irreversible evolution of time. Whyte (32) remarks the pyramids of the Pharaohs constitute an effort to escape from the transient character of life by building forms which are timeless. The same can be said about language systems and probably about all structures which man has created. Language systems are just like perceptive agregates, space and time buildings. But if we compare language with perception, we see that in language the tendency has come to a better result: repetition of language manifestations by any language user at any moment and unbounded by specific situations made language systems social constructions, where perceptive aggregates must necessarily be limited to individual organisms and perish with them. The space building becomes in language structures a social dimension and the relative permanence in time exceeds the individual existence of the language users.

What was relative permanence in perceptive and in linguistic structures has been realized in an absolute way in formal axiomatic systems. Once the formalization and axiomatization have been performed the system which results is withdrawn from any further alteration in time: the new theory has in the future a constant and permanent validity.

(32) Whyte, L.: *Accent on Form. An Anticipation of the Science of Tomorrow*; New York, Harper & Brothers, 1954.

If we consider the continually changing character of the external world and of the organisms within that world, it is striking to see how human culture tries at every moment in all its structures to create someting which is not subject to alteration: certainly this tendency has found a major realization in abstract structures which correspond to the deep necessity to give a permanent form to the a-priori side of human knowledge independent of the evolution of the world as well as of the passing away of individuals and linguistic groups, but at all times in an unchanged form available to human beings.

3.4. *Central and peripheral areas: horizontal dynamics and marginal variability.*

There is a topological flexibility of perceptual structures which makes them unchanged by variations within certain limits. In his structuring activity and for the recognition of these structures, man is not bound to an absolute and univocal reference of space and time. His structuring does not correspond with metrical parameters, but relies on the weaker conditions of a topological space. This aspect of structuring particularly has been put forward by Lewin ([33]). The important characteristic here is that a marginal variability is possible which permits us, little differences nothwithstanding, to account for irregularities and changes in the perceived field of reality and to interpret them in respect to the same perceptual structures.

This marginal variability is due to the fact that a certain and the most important part of the structures remains unchanged and this unchanged part is at once the oldest part of the structure and the most central. According to Goldstein ([34]) soldiers which were head-wounded during the First World War maintained intact these central parts of the structured patterns of reality much longer and much more easier than more complex patterns which involved elaboration of many more details perceivable in the external world.

Piaget ([35]) considers the gradual decentration as one of the characteristic genetic evolutions of visual perception. We can suppose therefore that in general in all perceptive structures there is a gradual integration of parts of the focused object, so that starting from a central set of data there is a regular extension to more peripheral events. But these peripheral events do not alter the already integrated part of the construc-

(33) Lewin, K.: *Principles of topological psychology.* New York, 1936.
(34) Goldstein, K.: *Der Aufbau des Organismus*; Den Haag, 1934.
(35) Piaget, J.: *La Psychologie de l'intelligence*; Paris, 1947.

ted aggregates. This explains the variability and flexibility of the perceptual structures within certain limits.

In the structure of a natural language system we discover equally that there are stylistic and therefore individual margins of variability which do not alter the language system as a whole. We find in De Boer ([36]) a distinction of "couches de fonction" within the structure of language, presented as concentric circles of primary, secondary and tertiary functions, where only the peripheral circles permit marginal variability : "c'est là, à la périphérie, qu'on trouve le terrain du "style", puisque c'est là seulement que l'individu aura une certaine liberté de choix dans la façon dont il se servira des signes syntaxiques."

In language structure we have degrees of integration just as in perceptive structures. The fact that the maximal integrated part is not influenced by accidental particularities underlines the fact that language structures, just as perceptive structures, are the result of an activity in a genetic process of the individual speaker himself. We remember here Gehlen ([37]) and his descriptions of "language roots" (Sprachwurzeln) which are all directed towards an individual construction of a language system by every child. Imitation of older people has here much more a selective than a creative influence.

The marginal variability of language structure can be explained by the hypothesis that every language user is continually engaged in developing his own language system and in this respect the social dimension would not be creative but on the contrary it would act as a social control mechanism by which other language users refuse or select certain stylistic innovations. In the last case the language system will be extended ; in the first case the system will only tolerate the marginal peculiarities.

The comparison of perception and language shows in this respect that in both structuring activities the individual tries to accommodate the "data" of the world to the structured system he has elaborated in his personal history : creativity dominates the expansion in the direction of integration of selected variations from the marginal peripheral areas. There is anyway a difference to note here again between this integration in perceptive and in language structure : in the long run a change in the environment of a certain importance cannot indeterminately be neglected. In language structure there are continual pressures from the group ensuring that too important particularities which are not accepted in the

(36) De Boer, C.: *Syntaxe du français moderne*; 2e uitg., Leiden, 1954.

(37) Gehlen, A.: *Der Mensch, seine Natur und seine Stellung in der Welt*; Bonn, 1950.

language system tend to disappear in the speaking habits of individual language users.

We now turn to abstract formal structures in order to see how this property of structures is represented here. It is easy to see that here again there is not only the same characteristic, but that we find this property in a maximal form. Consider first the status of the postulates : their fundamental property is just that they need not be true, because they are suppositions and presented in that way. So it will never come about that a logician will be obliged to change his postulate because it is not in accordance with the external world, as is the case with perceptive structures. On the other side the logical aspect leaves also complete liberty to any thinker because it is sufficient to state clearly what logical rules one wants to follow and then to follow them rigorously, to have a consistent and universally accepted system. In this respect there is a difference especially with language structures because there is no longer a social control as to what logical principles will be selected or rejected. The toleration has become maximal and all marginal variability needs only to be consistent with the system itself.

We can conclude here inductively that the property of being divided in central and peripheral areas is a property of all structures in human sciences. We cannot determinate how many different areas are to be distinguished and probably this will depend on the needs of the field of research. The distinction in central and peripheral areas is only a schematic one. In the work of Chomsky we see in fact that the concept of transformation works with a great number of distinctive stages which give another stage after each transformation.

An interesting application of the central-peripheral distinction is found in Rokeach ([38]) who applies the structural principle to distinguish different regions in a system of "beliefs". The central regions can generally not be altered and are often defended even against rational arguments. The intermediary regions can already be influenced though not always in an easy way. We have school formation, indoctrination and disindoctrination here. The peripheral region is where other opinions are considered as equivalent.

In politics we must consider any threatening of an alteration of the central regions of the political structures as a "casus belli" in the past and even unfortunately in our xxth century. It would be interesting to take this aspect of structures into consideration for modern polemo-

(38) Rokeach, M.: *The Open and Closed Mind.* New York, 1960.

logical studies. We hope to treat many of these subjects in a wider perspective.

3.5. *Levels in structure: Vertical dynamics and generality.*

There can be an interfacilitation or an opposition between different subsystems in the perceptive aggregate, which means that one subsystem can influence the elaboration of other subsystems in a positive or in a negative, inhibitory way. We are confronted here on a superior level with an effect of the closedness mentioned before: these facilitating or inhibiting effects would not be possible if the subsystems did not tend to constitute structures on a higher level, with the double result of attraction of what can be integrated on the higher level and rejection of what cannot be integrated.

In fact we have here a structural property which is a function of the tendency to generality, which is in turn the result of a necessity to limit the amount of information with which a human being has to deal. The paradox of perception put forward by Apostel (cf. 3.2.) is here again at work: if one says: "I see a woman with a dog", the speaker is supposed to perceive much more than that, but in accordance with the level principle we can reduce his perception to a focusing of a relation between two different aggregates and an inhibition of all aggregates which might be in the environment of the perceived objects. There is a level of perception which makes greater generality in perceiving possible and these more general levels on which perception works in daily life mean a reduction of the energy which must be available to classify and deal with the external world.

We compare now with structure in language and it is evident that there the levels are much more used and are developed to a greater extent. The phonological level, for instance, which determines the distinctions between the sounds is neglected in common speech to such a point that these "phonemic units" are not even perceived for themselves. We hear only "words" which means combinations of phonemic units. And modern didactic methods for learning foreign languages begin even by presenting whole sentences, the studying of words being only an ulterior analysing phase. A summary of a book or a paper means the adoption of an even higher level. In all these transitions of levels we attain a greater mesure of generality and this is a very important property of language structure.

Let us now see the difference between perceptive structures and language structures: the number of levels is much more restricted in perception, which means also that the degree of generality which can be obtained there is rather restricted. For language structures the levels are of

considerable number, especially because, as Martinet (39) says, language is "un système à double articulation" which means in fact that the structure of the basic level (words as combinations of phonemic units) keeps totally undetermined the structuring of the higher levels (syntactic structures). This aspect of language structure which is not present in perceptive structures is due of course to the arbitrary character of the linguistic signs which we have already seen.

In abstract structures we find a striking illustration of a division into different levels necessary for generalization in the appearance of the logical paradoxes and the introduction of a hierarchy of types by Russell (40) in order to avoid these paradoxes. A "type" is the range of significance of a propositional function, i.e. the collection of arguments for which the said function has values. The reflexive fallacies can be avoided by the "vicious-circle principle" i.e.: no totality can contain members defined in terms of itself; or in a more technical language: whatever contains an apparent variable must be of a type different from the possible values of that variable and in fact is of a higher type.

Why these different levels in perception, in language and in logical structures? It is a necessary condition for arriving at greater generality. And generality is a condition for explanation: we can say to a certain extend that we have explained something if we have formulated it in terms of the greatest possible generality. The greater generality implies that we can apply the "higher level object" to more fields of reality. By his explanations the human being enforces his influence on the external world.

3.6. *Tendency to Normativity.*

The perceptive structures tend to establish and maintain constant relationships: perceived intervals, shapes and forms can be retained notwithstanding variations in absolute sizes, of the constituent parts and of the whole. There is a stabilizing principle which makes it possible that invariant relationships are perceived amid a flux of changing stimuli. We have here, even at an almost organic level the principle of an ethical rule which has not here a social function, but a function of maintaining the elaborated structure unchanged in order to prevent the organism from wasting energy.

The patients of Goldstein (o.c.) try to maintain situations which they have already learned to perceive and handle. There is a general tendency

(39) Martinet, A.: *La linguistique synchronique*, 1965.

(40) Russell, B.: *Mathematical Logic as Based on the Theory of Types*, 1908; reprinted in: Marsh, R. (ed.): *Logic and Knowledge*, London, 1956.

in human structuring to respect the structures of perception, behavior and thinking which are already integrated and this tendency seems stronger in patients of which some organs, especially here the brain, have been dammaged, probably the amount of energy to be used for the working of the organ in question is too great to take account of all possible variations. The necessity to avoid catastrophic reactions makes it impossible to begin at any moment with total disorder.

Even at the level of perception man is obliged to introduce regularities, habits of perceiving. At a more conscious level this attitude will lead to rules and norms, for instance in language systems and logic. But it is interesting to notice that normativity exists already in perception: if we consider the number of stimuli with which man is confronted, we cannot suppose that the perceptive structures did "exist" in the external world before man was confronted with it; in other words the perceptive structure shows not only aspects of reality but also "the way in which the human being wants to see" that external reality. And it is precisely the latter aspect which constitutes the normative aspect of perceptive structures.

For language structures the normative aspect has been sufficiently underlined by the "normative grammars" of the past. We want to note here anyhow that normativity is not a social product in our point of view, but a characteristic of structures elaborated by human beings on an individual level. The social apect of language structures, which is not present in perceptive structures, is the adequate condition for an explicit formulation, but does not constitute the creative aspect, as is evident from the fact that normative grammars have "frozen" the evolution of language for many centuries.

For abstract structures we find an illustration of normativity in the principle of toleration of Carnap: everyone can build his own logic (creativity) on the condition that it is clearly formulated (condition for intersubjectivity) and rigorously followed (normativity). We see here that normativity is a necessary condition for creativity, but not a sufficient one. In fact this aspect of a tendency to normativity in structures seems very important to us because many fallacies can be avoided by this principle. We shall not enter into details here, but we want to point anyway at some of the consequences: (a) the structures determine their own normativity, which means that any search for normative rules must begin with an internal analysis of the structures; external considerations apply to other structures, of a higher order; (b) creativity of new structures (art, science, economics, etc.) will enhance new norms, but will be inhibited

(41) Goldstein, K.: *o.c.*

by preexisting ones. This is for instance the formal interpretation we give for an actual book about economic behavior in Europe by Servan-Schreiber (42) and it is in art illustrated by the decadence of French theater during the XVIIIth century after the influence of the normative work of Boileau (43). And there are other examples of course, which we generally indicate by "censorship".

There are interesting differences to note between the degrees of importance to which normativity reaches. In perception for instance the influence of normativity is less great than anywhere else, because there the structures are to a maximal extent determined by the external reality. But the influence of man is present and we find this aspect accentuated in art. Again we do not enter into detail here but art is in our opinion determined by the accentuation of the human normativity which finds its beginnings already in perception and can be incorporated in the reconstruction of reality to such an extent that the original external reality is often not easily recognized. Compare now with scientific research and there again there is an incorporation of certain aspects of human normativity, but now in a quite different direction. Generally speaking those aspects are incorporated which permit a better grip on reality and abstract structure presents an important aspect of this incorporation because here generalization is one of the dominating results of the maximum distance obtained from empiric reality.

3.7. *Tendency to Equilibrium: Aspects of Meaning.*

The perceptual aggregate constitutes an energetic cycle which shows the following stages: starting from an equilibrium in the perceived aggregate, there is a distortion of the equilibrium by influences from external reality. The distortion of the equilibrium has as a result a redistribution of the energies which make the system enter in a new stage of equilibrium of the same level of total energy. The return to the equilibrium after distortion by the external world constitutes the physiological process which makes perception possible as a partially open behavior i.e. directed to what is not under the control of the organism itself. The open system tends to a maximum of negative entropy and tends to maintain that level of organization for each perceived structure by affording at each moment the energy which is necessary.

At a first glance one would think that this property is only valuable for perceptive structures. And certainly this aspect has not much been

(42) Servan-Schreiber, J. J.: *Le défi américain*, Paris, 1967.
(43) Boileau, N.: *Art poétique*, 1674.

studied for language and probably not at all for abstract structures. We think anyway that this energetic aspect can be interesting, especially for the study of language structure, because this aspect would possibly permit integration of studies about frequency and other statistical aspects of language in a more complete theory of linguistics. The work of Zipf (44) for instance has been neglected for a long time; the energetic aspect recalls also the fact that no linguistic structure stands by itself, and depends always on the energic basis of an organism : only a used language is a structure and if we know nothing about the use, if we do not see the relations between the signs and organisms placed in different situations and executing activities, however abstract their character may be, we have but a collection of objects minus all relations, where there is no more structure, and from where language has disappeared.

It is easy to understand why the energetic aspect has often been forgotten in the study of certain structures : natural language and artificial languages can be studied apart from organism, which is not the case for perceptive structures. But is this not confounding the independence of language structure from organic support—which is erroneous as is proved by the disappearance of numerous dialects and idioms from the past because the language was no longer used—and the intersubjective character of language structure which ensures that each individual language user can be replaced without noticeably changing the language structure? Although language structure are stated as objects, and are often confounded with objects, i.e. existing independently of human support, this is a misconception resulting probably from a misplaced application of the views about "objects of research' which comes from natural sciences. The autonomy of language structures is but an apparent one.

We come now to a hypothesis which we cannot develop further here: human structures receive from man the characteristics of his own organism. Structures are man built outside himself (45). If we apply this principle here we find the energetic cycles of the perception structures again in language structures, but now in a new form : with energetic cycles correspond here semantic cycles. The tension between organism and external environment which is on the level of the organism an internal energetic tension which must continually be maintained, is extended to the medium of language structures.

(44) Zipf, G. K.: *The Psycho-Biology of Language: an Introduction to Dynamic Philology*; 1935; reprinted as a paperback by M. I. T. Press, 1965, Cambridge, Mass.

(45) Many of the points of view which we indicate here will be treated in detail in a doct. diss. which we prepare.

Let us now compare the energetic equilibrium of perceptive structures, which is the result of a continual effort of the organism, with the equilibrium in the field of semantics: in the latter region there is an organization which permits an equilibrium without necessity to go outside of the semantics of language, which consists for instance in the reversibility of each semantic operation. By the means of negation, by oppositions in meanings of words and of sentences language systems always offer the possibility of undoing the semantic situation. Semantically speaking a sentence could be defined as a distortion of a semantic equilibrium. Now, what we call the semantic cycle here is the possibility to arrive again at a state of equlibrium without leaving the field of semantics.

Reversibility is certainly not the only semantic property of language structures, but it is an important aspect, which means that in principle semantic cycles are possible. The fact however that natural language is closely related to external reality and concrete situations of behavior means that, as a rule, semantic equilibrium cannot be obtained within the field of semantic systems in natural languages. That would probably lead to magic practices as a prevailing characteristic of language use.

Man has succeeded to a maximum extent in keeping a semantic equilibrium within a totally internally determined system with the elaboration of astract structures. By introducing postulates, there is no longer dependence on external facts and the formal systems can be created in such a way that every distortion comes from the characteristics of the system itself and can be allowed for within the system.

If we compare now the way in which equilibrium is maintained in the three kinds of structures with respect to meaning we can establish (a) that if we want to speak about meaning it can only be an energetic basis within the organism; (b) that there is a different organization of the structures of perception, language and logic tending to minimize as much as possible the distortion which comes from outside the structures. The meaning of "meaning" is a function of a gradual difference in the success of arriving at more easily obtained equilibria. The general definition of meaning for all structures seems to be: the energetic tension necessary to deal with structures within the limits of equilibrium.

We can imagine that not everyone will be immediately satisfied by this meaning of "meaning", and here again we can but indicate briefly what is in fact one of the great problems of "structure". By pointing at the relation between meaning and equilibrium of energetic levels we wanted to indicate here that there is a place for the problem in our definition of "structure"; we do not think that all problems have been solved. We shall not omit to point also to a relation between our definition of meaning

here and the definition of intelligence in Piaget ([46]) who refers also to the aspect of equilibrium of psychological structures.

3.8. *Foreground and Background in Structures: The Phenomenon of Consciousness.*

Allport ([47]), puts forward a property of perceptive aggregates which he calls "energetic weighting and pooling". The energies of the events which constitute the elements of the perceptual aggregate form together an algebraic sum : they arrive at an average of their values. Perceptions involve the complex density of a great number of specific energetic actions. In constructing the aggregate the different inputs are not always equal, but they can be enforced in accordance with specific conditions. This enforcement of a specific input corresponds to the degree of relevance of certain aspects of the aggregate as a cognitive means in relation to a goal structure. As a common denominator of all energies we can consider the amount of energy which is present within the perceptual form of the aggregate during the activity of perception.

We have here again an energetic property which we compare with the foreground-background relation on the organic level put forward by Goldstein, who considers this relation as fundamental for the distribution of energies within the organism : the nervous system is never at rest (background) and there are ganglia with can concentrate the tension caused by a certain stimulus so that a high intensity of excitation can be obtained (foreground). In the same way a reaction at internal stimuli must be possible so that the result is a high degree of concentration.

The same idea of foregound-background is certainly present in the distinction "parole—langue" of de Saussure, representing on one side the actual use of language (foreground) and on the other side the virtual system of language present in the linguistic consciousness of the language users (background). In fact the relation foreground-background constitutes also the basic problem in the work of Chomsky ([48]), as he always tries to describe by his generative grammars how the individual speaker can arrive at the production of an infinite number of possible sentences on the basis of a finite number of linguistic observations. "The most striking aspect of linguistic competence is what we may call the "creativity of language", that is the speaker's ability to produce new sentences, sentences that are

(46) Piaget, J.: *o.c.*

(47) Allport, F.: *o.c.*

(48) Chomsky, N.: *Aspects of the Theory of Syntax*; The M. I. T. Press, Cambridge, Mass., 1965.

immediately understood by other speakers although they bear no physical resemblance to sentences which are familiar". The creativity is here in fact the possibility of passing through the field of the virtual language system, using the current rules of combinations, but choosing a path that has possibly never been taken. Such a new path would not be situated by the other language users if the whole system of language were not continually present in the mind, so that it is sufficient to hear a sentence to put to the foreground the whole part of the language system which is necessary to locate the sentence and thereby understand it.

The foreground-background relation seems also to be present in scientific research on abstract structures, in pure mathematics and in logic. We think therefore that we can inductively conclude with the hypothesis that this property is present in all human structures.

We consider this background-foreground relation as the necessary condition for consciousness, which means that we see consciousness as the foreground-background result of an activity within the field of a structured system. The fact that we speak about activity implies already that we consider the energetic basis necessary, which would be trivial if this aspect had not been forgotten so often; the foreground-background relation implies that there must be a learning process necessary before consciousness is possible, a process during which the structuring of the whole system is elaborated, and which can take millions of years on the phylogenetic level and quite a number of years on the ontogenetic level; the condition of the structured system implies that culture is a necessary condition and that consciousness is a function of the degree of differentiation and richness of the available structured systems. As an example it follows that self-consciousness, which is a special case of consciousness, is not possible without a social system where each individual has a place so that the individual place can be put in the foreground with the whole social system as background. Such a feeling can only last for a longer period of time if there is a language system in which different groups and individuals are represented.

We define here consciousness as an energetically based activity of establishing a foreground-background relation within the field of a structured system (which can vary from perceptive systems to social systems, language systems, art, behavior systems, beliefsystems, etc.). Here again we want to show by this definition that there is a place for the phenomenon of consciousness in our definition of structure.

4. Conclusion

We have tried to give a definition of structure and we were obliged to differentiate according to the different language systems where the definition was to hold. The most interesting is probably the "real" definition, presented as a set of properties of the concept of structure which is to hold for the language system of science.

We hope that we have given a contribution to the problem of "structure" which is so important because it appears finally to be an important aspect of the problem of science itself.

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