

Cognitive Strategies

Humberto R. Maturana

My purpose in this article is to discuss cognition in relation to man and the unity of man, in an attempt to show that any notion that we may have about the unity of man is bound to our views about knowledge and reality. Since everything that I say is said as an observer addressing other observers, I shall consider the statement that “any human action implies knowledge” as a sufficient experiential characterization of cognition, and let any additional connotation arise in the course of the article.¹

A. The objectivity of knowledge.

Present views about cognition as they are generally held by scientists, both explicitly and implicitly, are founded in the following epistemological notions.

Notion 1. We exist in an objective world that can be known and about which we can make cognitive statements that reveal it as an independent reality whose validity is, therefore, independent from us as observers.

Comment: Although experientially this notion seems proven by the very circumstances that generate it, namely by our day to day manipulative experience and the predictive success of our operation as physical entities, it is an *a priori* notion because a successful prediction does not prove that the operation through which we make it reflects an objective reality, or constitutes an expression of our cognitive access to this reality. A prediction is a statement of what is the case within a relational matrix. Accordingly, if by some observational procedure the phenomenon considered is revealed through a projection onto a relational matrix, any statement of what is the case in that relational matrix will necessarily be observed as a state of the matrix onto which the phenomenon considered can be projected in the act of observation. Therefore, the success of a prediction only proves that a certain mapping or projection operation can be made, but does not reveal the nature of what it is that is mapped or projected.

Notion 2. We obtain knowledge through our sense organs by a process of mapping the objective external reality onto our nervous system, accomodating our behaviour to the structure of the world revealed through this mapping.

¹Source: Heinz von Foerster, *Cybernetics of Cybernetics*, BCL Report no. 73–38 (Urbana: Biological Computer Laboratory, Department of Electrical Engineering, University of Illinois, 1974).

Comment: This notion seems proven by electrophysiological experiments that show that there are nerve cells that appear to function as filters or detectors of describable environmental configurations such as edges or directions of movement. To the extent that these cells seem to reveal an independent reality, they appear as perceptual operators that represent the external world in the activity of the nervous system. The objection is rather obvious, however, that it is a general feature of all filters that their organization determines what passes through them and, hence, they can only reveal that certain mapping operations can be made. So if nerve cells do act as filters, it would not be possible to distinguish any objective feature of the outside world through them. This same criticism also applies to instruments. The genetic argument that our present day organization is the result of evolution, although valid with respect to the origin of the structure and operation of our sense organs as components of our organism, does not solve the cognitive problem. If our sense organs function as filters we cannot use them to make any objective statement about the external world—unless we possess a Maxwell's demon with access to absolute knowledge who observes the product of our sense organs' operation, and acts on this product as we supposedly do on the outside world.

Notion 3. Information represents an actual physical magnitude that can be measured objectively as a property that characterizes the organization of an observable system.

Comment: According to this notion, the organization of any system can be analyzed and described in a non-trivial manner in terms of its information content. According to this notion, also, living systems are considered to be systems that process the information that they gather through their sense organs, and thus are able to make objective statements about the outside world. The use of the notion of information for the analysis of biological systems, is, however, fallacious for the following reasons:

- i) The notion of information is in fact a cognitive notion that refers to the observer's uncertainty with respect to the system, situation or phenomenon under consideration, not a notion that refers to a physical magnitude, even though the mathematical expression of its measure is formally similar to the expression of entropy. In engineering terms the measure of information is a measure of the frequency of occurrence of a given phenomenon as a function of its probability, and as such constitutes a cognitive statement. Furthermore, it is a cognitive statement that can be used to characterize a system only *a posteriori*, that is, after the system has been sufficiently characterized in operational terms so that its possible states and their probabilities may be assessed.
- ii) Since in order to characterize a system in informational terms one must know the system completely, doing so with an already known system is to make a trivially redundant description, and doing so with an incompletely known system as if it were known is a mistake. If, on the contrary, one attempts to design a system, the use of information concepts to assess the domain of its possible states is a non-trivial affair.
- iii) Due to his cognitive operation, an observer frequently attaches semantic value to the biological phenomena considered by him as if this semantic value participated as a component in the mechanism of their realization, which cannot be the case because meaning is a contextual relation. This, for example, occurs in genetic description when one speaks about the genetic code as if the nucleic acids constituted signals in a system of communication, which is obviously not the case because they are constitutive components of the process of protein synthesis. Thus, to speak about the coding of genetic information in the nucleic acids is acceptable in a situation in which the listener essentially

knows what one is talking about, but is a mistake if one wants to provide a mechanistic representation of the genetic phenomena. This problem is aggravated by a frequent confusion of notions when information and meaning are considered as equivalent in the attempt to quantify semantic problems.

- iv) It is said that living systems obtain information from the environment and process it to generate their conduct, and that their organization can be characterized in terms of this capacity. That this cannot be properly done should by now be obvious, yet let me add the following: The states and the transitions of states of any system is determined by its organization. Accordingly, the states of the sense organs and of the organism (nervous system) as well as their transitions are necessarily determined by their organizations, and the environment as a perturbing agent can only act as a historical instance for their occurrence, not however for their determination. Therefore any uncertainty about the course of change followed by the sense organs and the organism as a result of an interaction is merely cognitive, belonging to the domain of observation. The notion of information does not apply as a characterization of the operation of the nervous system.

B. Objective knowledge and the unity and diversity of man.

Current views about the unity and diversity of man are, generally, implicitly or explicitly, subordinated to the notions discussed above, and adopt fundamentally three forms.

Expression 1. Men are genetically equivalent to the extent that they belong to the same species, and all human diversity is either due to genetic variability within this fundamental equivalence, or to up-bringing (cultural and physical environmental differences during ontogeny) , or to both.

Comment: The validity of the notion of the fundamental genetic equivalence of man is not to be questioned. In fact, human membership in a single species is basic to any notion of human unity because it constitutes the condition of their possibility: Sexual recognition. Mankind is defined by the very biological operation through which men are generated. The cognitive implications, however, vary according to the notion of reality under which the biological unity of man is considered. Thus, if one accepts, as is usually done, the notion of an objective reality accessible to our cognition, human diversity, whichever way it arises, would not represent an intrinsic diversity in the cognitive domains of different men but only a circumstantial difference in their access to this objective reality. The relation between ontogeny and cognition, or between experience and cognition, under this view, is merely contingent, and not determinant.

Expression 2. Cultural differences only reflect a different mode of treating an objective reality.

Comment: If there is an objective reality, cultural differences can only represent different modes of treating it, and have no other justification than the historical contingencies of their origin associated with the basic conservatism of biological processes. Therefore, under this view the toleration of cultural differences is, by necessity, an expression of their acceptance from the perspective of better knowledge, and not the recognition of their legitimacy as expressions of different but valid cognitive domains. Also, cultural change can only be viewed as either a social transformation towards the proper cultural treatment of the

objective reality (that is, towards a society founded in scientific knowledge), or as a social transformation away from such a treatment (that is, towards a society founded on subjectivism). However, since knowledge of an objective reality could not be denied if we had it, under this view the course of cultural change can only be, in the long run, unidirectional, and social strife can only be the confrontation of truth and falsehood.

Expression 3. The cultural unity of man can only be obtained through the development of a culture in which men base their conduct on objective knowledge; that is, through the development of a culture in which men have the right way of looking at reality.

Comment: To the extent that we live in an objective world accessible to our knowledge, it seems legitimate to expect that all human differences will lose significance if indeed men learn to look at the world objectively, and to act accordingly. In fact, the belief in that this is the right approach is implicitly or explicitly present in all modern political or sociological strife, and all the parties involved adduce the argument of objectivity in support of their positions and as a justification for their intolerance and negation of other views. This is, however, the only consistent attitude possible to anyone who thinks that he has access to an objective truth, whether by revelation or through scientific inquiry.

C. Cognition as a subject dependent phenomenon.

My criticism of the notion that we have cognitive access to an objective reality is not new. In fact, philosophers, psychologists, and biologists have on many diverse occasions argued that the act of cognition is somehow bound to the knower. Unfortunately, philosophers and scientists generally feel that recognizing that cognition is a subject dependent phenomenon leads to idealism and to solipsism. I think that this should not be the case and that there are two basic sources to this fear:

- i) It is difficult for us as western thinkers to imagine cognition as a subject dependent phenomenon because we live immersed in a denotative linguistic domain in which even subjective notions are expressed denotatively, as if their existence were independent of us as observers.
- ii) It seems that a biological mechanism that gives rise to an observer with a subject dependent cognitive domain in which he uses a denotative language with manipulative success is a paradox, and hence, impossible.

Although I shall not attempt in this presentation a full discussion of the problem of cognition, I shall endeavour to show that, biologically, cognition is constitutively a subject dependent process, and that solipsism arises as a problem only if we insist on demanding from a subject dependent cognitive domain the properties of subject independent cognitive domain.

Statement 1. Cognition as a process is constitutively bound to the organization and structure of the knower because all the states and interactions in which the knower can enter are determined by his organization and structure. This statement implies the idea that cognition is a biological phenomenon.

Comment: The domain of states that a system can adopt without loss of identity is necessarily determined by the organization which defines it and the structure which realizes it. If a system is deformed in a manner not prescribed by its organization and structure it disintegrates. Accordingly, the problem of understanding the cognitive domain of a living system as the domain of its possible states is subordinated to the understanding of its organization as a living system and its structural realization as a particular concrete unity. In relation to this the following considerations are pertinent:

- i) Every unity is either an unanalyzable whole (or can be treated as such) endowed with properties that define it, or it is a complex system realized through the properties of its components. If the latter is the case, the complex system is defined as a unity by the relations that its components must satisfy to constitute it, and its properties as a unity constitute its organization. Therefore, to characterize the organization of any system it is necessary and sufficient to point to the relations that define it as a unity. The components and the actual relations between components that realize a particular system as a concrete entity constitute its structure.
- ii) Present day biological knowledge allows us to say that a living system considered as a unity in the physical space, that is, as an entity topologically and operationally separable from the physical background, is defined by an organization that consists of a network of processes of production and transformation of components, molecular and otherwise, that through their interactions: a) recursively generate the same network of processes of production of components that generated them; and b) constitute the system as a physical unity by determining its boundaries in the physical space. This organization I call the *autopoietic system*. Due to this organization a living system is an autonomous unity, self-assertive in its dynamic capacity to withstand deformation under continuous turnover of matter while remaining invariant in its organization.
- iii) Since a living system is defined as a unity by its autopoietic organization, all the transformations that it may undergo without losing its identity are transformations in which its organization remains invariant: an autopoietic system is a homeostatic system that has its own organization as the essential variable that it maintains constant through its operation. Therefore, all the unitary phenomena of an autopoietic system are constitutively subordinated to the maintenance of its autopoiesis.
- iv) Mechanistic systems (machines) whose organization is not autopoietic do not produce the components that constitute them as unities, and, hence, the product of their operation is different from themselves. The physical unity of these systems is determined by processes that do not enter in their organization. These systems or machines, which I call *allopoietic systems*, have, by their constitution, input and output relations as a characteristic of their organization: their output is the product of their operation, and their input is what they transform to produce this product. The phenomenology of an allopoietic machine is the phenomenology of its input-output relations. In autopoietic systems the situation is different. For an autopoietic system as a homeostatic system that has its own organization as the essential variable that it maintains constant all the states that it can adopt without disintegration are equivalent in that they all necessarily lead to the maintenance of its organization. The product of the operation of an autopoietic system as autopoietic system is, under all circumstances, itself. Therefore, autopoietic systems are, by their constitution, closed systems without inputs or outputs. They can be perturbed by independent events, but the changes that they undergo as a result of these perturbations, as well as the relations of autopoiesis that these changes generate, occur, by their constitution, as internal states of the system regardless of the nature of the perturbation. An observer may treat an autopoietic system as if it were an allopoietic one by

considering the perturbing agent as input and the changes that the organism undergoes while maintaining its autopoiesis as output. This treatment, however, disregards the organization that defines the organism as a unity by putting it in a context in which a part of it can be defined as an allopoietic subsystem by specifying in it input and output relations.

From these considerations, it follows that since we are living systems all our phenomenology as individuals is subordinated to our autopoiesis, otherwise we disintegrate; therefore, as individuals we are closed systems. It also follows that cognition as a phenomenon of the individual is subordinated to the autopoiesis of the knower, and that all cognitive states as states of the knower are determined by the way its autopoiesis is realized, not by the ambient circumstances in which this takes place. Cognition is constitutively a subject dependent phenomenon. The changes of state that the autopoietic system undergoes while compensating for perturbations can be treated by an observer, who sees it in a context (environment), as actions exerted by the organism on the environment, and he can attach to them operational meaning in relation to the perturbing circumstances that he sees acting upon the organism. Such meaning, however, lies exclusively in the descriptive domain of the observed organism as an autopoietic system.

Statement 2. The nervous system is a closed network of lateral, parallel, sequential and recursively interacting neurons.

Comment: The closed organization of the nervous system is apparent in its changes of state. In fact, operationally the nervous system is a closed network of interacting neurons such that a change in the state of relative activity of a group of neurons always leads to a change in the state of relative activity of other groups of neurons, either directly through synaptic action, or indirectly through the participation of some physical or chemical intervening element. Therefore, the organization of the nervous system as a finite neuronal network is defined by relations of closeness in the neuronal interactions generated in the network. Sensory and effector neurons, as they would be described by an observer who sees an organism in an environment, are not an exception to this because all sensory activity in an organism leads to activity in its effector surfaces, and all effector activity in turn leads to changes in its sensory surfaces. That at this point an observer should see environmental elements intervening between the effector and the sensory surfaces of the organism is irrelevant because the nervous system is defined as a network of neuronal interactions by the interactions of its component neurons regardless of any intervening elements. Therefore, as long as the neuronal network closes onto itself, its phenomenology is the phenomenology of a closed system in which neuronal activity always leads to neuronal activity. This is so even though the ambient can perturb the nervous system and change its states by coupling to it as an independent agent at any neuronal receptor surface. The changes that the nervous system can undergo without disintegration (loss of defining relations) as a result of these or of any other perturbations are fully specified by its connectivity, and the perturbing agent only constitutes a historical determinant for the occurrence of these changes. As a closed neuronal network the nervous system has no input or output, and there is no intrinsic feature in its organization that would allow it to discriminate, through the dynamics of its changes of state, between possible internal or external causes for these changes of state. This has two fundamental consequences:

- i) The phenomenology of the changes of state of the nervous system is exclusively the phenomenology of the changes of state of a closed neuronal network. This means that for the nervous system as a neuronal network there is no inside or outside.

- ii) The distinction between internal and external causes in the origin of the changes of state of the nervous system can only be made by an observer who sees the organism (or the nervous system) as a unity and defines its inside and outside by specifying its boundaries.

It follows that it is only with respect to the domain of interactions of the organism as a unity that the changes of state of the nervous system may have an internal or an external origin, and, hence, that the history of causes for the changes of state of the nervous system lies in a phenomenological domain different from the changes of state themselves. To the extent that no distinction can be made through the activity of the nervous system between its internally and its externally generated states, no distinction is possible through the activity of the nervous system between perception and hallucination. Such a distinction can only be made by an observer who sees the organism and its environment, because it is he who establishes a relation between a change of state of the nervous system and the environmental circumstances in which this change of state takes place. Hallucinations pertain to the domain of observation, not to the domain of experiences. There are two additional considerations to be made:

- i) Whatever the circumstances under which there is a change in the neuronal relative activity in the nervous system of an observed organism, all that the observed nervous system can do is to generate new states of neuronal relative activity that will recursively generate new states of neuronal relative activity and so on.
- ii) The nervous system in its operation as a closed neuronal network does not act upon the environment. In fact, the environment does not exist for the operation of the nervous system, it exists only for an observer, and it is only for him and in his domain of description that any action upon the environment can take place. It follows that it is only for an observer that the different states of the nervous system can be construed as representations of the environment of the organism, and that representations play no role in the operation of the nervous system as a neuronal network. However, although representations pertain to the domain of observations only, they reflect in this domain a coupling of the closed phenomenology of the nervous system with the independent (open or closed) phenomenology of the ambient.

Statement 3. The nervous system is coupled to the organism that it integrates in a manner such that its plastic connectivity is continuously being determined through its participation in the autopoiesis of the organism. Therefore, the connectivity of the nervous system is coupled to the history of interactions of the organism to which it is coupled.

Comment: The coupling of the nervous system and the organism takes place in three ways, all of which result in the subordination of its connectivity to the ontogeny of the organism:

- i) The organism, including the nervous system, provides the physical and biochemical environment for the autopoiesis of the neurons (as well as for all other cells), and, hence, is a source of physical and biochemical perturbations that may alter (even through the control of genetic expression) the properties of the neurons and, thus, lead to ii) or iii).
- ii) There are states of the organism (physical and biochemical) that change the state of activity of the nervous system by acting upon the receptor surfaces of some of its component neurons, and, thus lead to iii).

- iii) There are states of the nervous system that change the states of the organism (physical and biochemical) and, thus, lead recursively to i) and to ii).

Due to its coupling with the organism, the nervous system necessarily participates in the generation of the relations that constitute the organism as an autopoietic unity. Also, due to this coupling, the organization of the nervous system is necessarily continuously determined and realized through the generation of neuronal relations internally defined with respect to the nervous system itself. As a consequence, the nervous system necessarily operates as a homeostatic system that maintains invariant the relations that define its participation in the autopoiesis of the organism, and does so by generating neuronal relations that are historically determined along the ontogeny of the organism through its participation in this ontogeny. This has the following implications.

- i) The changes that the nervous system undergoes as a homeostatic system while compensating for deformations, which it suffers as a result of the interactions of the organism (itself a homeostatic system), cannot be localized to any single point in the nervous system, but must be distributed through it in a non-random manner, because any localized change is, in itself, a source of additional deformations that must be compensated for by further changes. This process is potentially endless. As a result, the operation of the nervous system as a component of the organism is a process of continuous generation of significant neuronal relations, and all the transformations that it may undergo as a closed neuronal network are subordinated to this. If, as a result of a perturbation, the nervous system fails in the generation of the neuronal relations significant for its participation in the autopoiesis of the organism, the organism disintegrates.
- ii) Although the organism and the nervous system are closed atemporal systems, the fact that the organization of the nervous system is determined through its participation in the ontogeny of the organism makes this organization a function of the circumstances that determine this ontogeny, that is, of the history of interaction of the organism as well as of its genetic determination. Therefore, the domain of the possible states that the nervous system can adopt as an atemporal system is at any moment a function of this history of interaction, and without representing it implies it. The result is the coupling of two constitutively different phenomenologies, the phenomenology of the nervous system (and organism) as a closed homeostatic system, and the phenomenology of the ambient (including the organism and the nervous system) as an open non-homeostatic system that are thus woven together in a manner such that the domain of possible states of the nervous system continuously becomes commensurate with the domain of possible states of the ambient. Furthermore, since all the states of the nervous system are internal states, and the nervous system cannot make a distinction in its processes of transformation between its internally and externally generated changes, the nervous system is bound to couple its history of transformations as much to the history of its internally determined changes as to the history of its externally determined changes of state. Thus, the transformations that the nervous system undergoes during its operation are a constitutive part of its ambient.
- iii) The historical coupling of the nervous system to the transformations of its ambient, however, is apparent only in the domain of observation, not in the domain of operation of the nervous system, which remains a closed homeostatic system in which all states are equivalent to the extent that they all lead to the generation of the relations that define its participation in the autopoiesis of the organism. The observer can see that a given change in the organization of the nervous system arises as a result of a given interaction of the organism, and he can consider this change as a representation of the circumstances of the interaction. This representation, however, as phenomenon, exists

only in the domain of observation, and has a validity that applies only to the domain generated by the observer as he maps the environment onto the behaviour of the organism by treating it as an allopoietic system. The change referred to in the organization of the nervous system constitutes a change in the domain of its possible states under conditions in which the representation of the causing circumstances do not enter as component.

- iv) Through this coupling, the ontogeny of the organism is a function of the operation of the nervous system, and, since the properties of the neurons (as determined by their internal organization and morphology) are a function of the ontogeny of the organism, the nervous system participates in the specification of its component neurons. Furthermore, since the properties of the neurons determine the connectivity of the nervous system, this participates through them in the specification of its own connectivity. Therefore, through this coupling the connectivity of the nervous system is a function of the ontogeny of the organism. Finally, since the closed phenomenology of the organism's autopoiesis is coupled to the phenomenology of the ambient: through its compensation for perturbations, the ontogeny of the organism is a function of the organism's history of interaction, and, therefore, the connectivity of the nervous system is a function of this history. It follows that the connectivity of the nervous system changes along the ontogeny of the organism, coupled to the changes in the way in which the autopoiesis of the organism is realized.
- v) Since history as a phenomenon is accessible to the observer only in the domain of descriptions, it is only in this domain that history participates in the generation of the observer's behaviour. This, in fact, takes place. Descriptions as linguistic behaviour constitute a source of deformations of the nervous system, and, hence, part of its ambient. Accordingly, the phenomenology of transformation of the nervous system discussed above also applies to the interactions of the organism in the domain of descriptions, and the structure of the nervous system is also a function of the history of interaction of the organism in this domain. The implications are obvious. All elements of the domain of descriptions, even though they do not represent states of the nervous system, constitute causal components in the domain of behaviour of the organism; such is the case, for example, with notions like beauty, freedom and dignity. They arise, as dimensions in the domain of behaviour of the organism through distinctions in this domain, from the coupling of the phenomenology of the nervous system and the domain of interactions of the organism, and have, therefore, behavioural value.
- vi) As an evolutionary consequence of the constitutive coupling of the nervous system and the organism, the genetically determined architecture of the nervous systems of different species is different. Yet due to this same coupling, the actual connectivity of the nervous system that is realized in each individual of a species, within its genetically determined range of possibilities, is specified along its ontogeny through its history of interaction.

D. Subject dependent knowledge and the unity and diversity of man.

Conclusion 1. Men as members of a single species partake of the same pattern of genetically determined organization, both in their general mode of autopoiesis and in the architecture of their nervous systems. This structural unity constitutes the basis for any cultural unity.

Comment: The genetic unity of man determines the domain within which are realized the individual variations in the human mode of autopoiesis and in the human mode of connectivity of the nervous system. Which particular autopoiesis and which particular connectivity of the nervous system are actually

realized in each man depends, however, on the particular circumstances of each ontogeny. Therefore, if the individual histories of different men resemble each other, their autopoiesis and neuronal connectivities will undergo transformations that are commensurate with their similar modes of life. They will have similar modes of conduct under similar perturbations: their cognitive domains will be similar. A culture, then, is by necessity a historical system of relations that constitutes a domain of specification of the cognitive domains of its members by determining their possible histories of interactions.

Conclusion 2. Cultural differences do not represent different modes of treating the same objective reality, but legitimately different cognitive domains. Culturally different men live in different cognitive realities that are recursively specified through their living in them.

Comment: To the extent that cognition is a subject dependent process, an individual can only exist in the cognitive reality specified by his particular mode of autopoiesis and neuronal connectivity. It is, therefore, a mistake to talk of any cultural limitation in the cognitive access to an objective reality. This simply does not exist. Also, there is no objective notion by which any culture can be deemed more adequate than another. Values are necessarily relative to the culture in which they arise, and cultures are necessarily relative to their own histories. Furthermore, all cultures are necessarily successful in the predictive domain that they define, and to accuse any one culture of failure from the perspective of another culture is an error. Cultural differences, then, are legitimate and must be respected, because they represent completely. valid cognitive domains, not because they are human expressions.

Conclusion 3. The problem of the cultural unity of man is not a problem of learning a single valid cognitive approach to an objective reality, but is the problem of generating a common subject dependent behavioural domain that defines a common subject dependent reality.

Comment: If there is no possibility of objective knowledge, this should not be taken as a guide to our conduct. If human cognitive diversity is the result of different ontogenies, the problem of human unity is the problem of generating an experiential domain which will lead to similar ontogenies. Societies, by constituting the ambient in which a man lives, restrict and determine his domain of possible experiences; conversely, men constitute societies and specify their nature through their conduct. Thus, men, through the society that they integrate constitute a cultural system as a homeostatic system that maintains the unity of the cognitive domains of its members by specifying both their concrete and their conceptual experiences. Therefore, the problem of the cultural unity of man is the creation of the conditions that define a collection of human beings as a cultural unity. This can be attained in a non-coercive manner only by defining a fundamental aim valid for all men through their biological unity such that its pursuit leads to experiences that make these men desire its aim.

E. Cognitive strategies.

In coming to the end of this series of considerations, the statement of our problems seems very similar to what it would have been at the beginning. Our understanding of it, however, is, I hope, different. In fact, since we cannot talk about an objective reality, we must recognize that all reality is subject dependent, and if we do that, three things should be apparent:

1. Science is not a domain of objective knowledge, but a domain of subject dependent knowledge defined by a methodology that specifies the properties of the knower. In other words, the validity of scientific knowledge rests on its methodology, which specifies the cultural unity of the observers, not in its being a reflection of an objective reality, which it is not. The implications are clear:
 - i) For epistemological reasons that arise in the culturally unified cognitive domain of our scientific thought, we need a substratum for existence, yet we cannot make any objective statement about this substratum because such a statement would arise in our subject dependent cognitive domain.
 - ii) The question of solipsism arises only as a pseudo-problem, or does not arise at all, because the necessary condition for our possibility of talking about it is our having a language that is a consensual system of interactions in a subject dependent cognitive domain, and this condition constitutes the negation of solipsism.
2. The problem of the cultural unity of man is not a problem of knowledge but a problem in the use of knowledge, therefore an ethical problem. Objective knowledge does not exist, consequently there is no basis for human cultural unity other than our desire to have such for reasons having to do with us as men. The reasons are clear. In our subject dependent cognitive domain there are grounds for viewing all men as equivalent: we recognize each other experientially (sexual recognition) as members of the same species. This is unavoidably knowledge because it is bound to our definition as men. As a result there are some of us who want this biological unity to be cultural as well as in reference to the conditions of existence. There are others whose wants are otherwise, and want the cultural diversity to represent a biological discontinuity. In either case we make an ethical choice; which way we choose, however, depends on our personal history of experiences, and, therefore, on our individual cognitive domain.
3. A decision is a choice between several alternative actions that is determined by relations proper to a domain different (a meta-domain) from the domain in which the alternative actions take place, and from the perspective of which the several possible actions are not equivalent. Therefore, from the perspective of the domain in which the actions take place the choice of one of them is an expression of preference, an arbitrary action in that domain, *i.e.*, an action with a meta-determination. Yet, reason is compelling. Given a set of premises as a starting point the outcome of an argument is determined; no alternative arises and no decision is ever made along it. If no mistake is committed the result of the argument can be rejected by an observer only because he does not like it, or because he does not accept the starting premises, and in either case the rejection has a meta-determination.

Ethical decisions are expressions of preference in the face of alternative actions that affect the lives of other human beings, and as such they are not determined by the knowledge of the consequences of the preferred action. but by the desire that the consequences of that action take place. Yet, for every human being, his subject dependent domain of alternatives over which he projects the world that he wants to validate with his actions. Therefore, although knowledge does not and cannot determine an ethic, ethics as a domain of preference determines the use of knowledge. Thus, we cannot escape the conclusion that the possibility of cultural unity in man rests exclusively on the possibility that all men may have the same ethic, and, hence on the possibility of creating for all men a common domain of experiences that should give rise in them to similar ethical preferences. The attainment of cultural (ethical) unity in man, then, is not a problem for science as we usually understand it, but is a problem in the art of living.

Many times in the course of human history men have tried to attain ethical unity through religious and political doctrines. These, however, are systems designed to reduce the individual variability of the human

beings as social members by specifying their domains of experiences and by forcing them through well defined hierarchical relations that end with the subordination of men to men; to acquire the structures that determine in them the desired modes of conduct (ethics). This has led to the world of oppression, exploitation and self-delusion in which we presently live. The question remains, however, of whether it is possible to obtain in man an ethical unity that denies human oppression. Which experiences should we choose for ourselves as well as for other human beings so that, as a result of them, we all want, consciously and unconsciously, to generate with our conduct a society in which no man is systematically restricted by or subordinated to other men, and to generate such a society by means that do not negate this desired end, however complex and changing this society may be?

The answer is not easy. Due to the nature of our cognitive domain, we can always enlarge or restrict this domain through our experiences, and one of the things we westerners can always do is to conceptually step out of our social system and look at it. This is in itself an experience that may change a man's ethic and transform him into a revolutionary, that is, into a man whose ethic is different from that implied by his social system, and who negates such a social system by validating a different one with his conduct. Ethical change leads to revolution. It is for this reason that coercive societies, through economic, religious, political and military coercion, deny their members the possibility of being observers of their own social system, and, hence, of changing it towards a more desirable one.

DESIRES

The spontaneous ontogenic course of a biological unity is always towards the stabilization of the relations that define it as a unity, that is, towards the stabilization of the hierarchical relations that hold between its components. This implies either an ontogenic stabilization of the properties of the components, or the ontogenic development of processes that make the components dispensable when their properties have changed, or both. The first case is undesirable because it implies the negation of man as an observer (totalitarian societies), that is, a negation of man as a social component who can step out of the system that he integrates and judge it ethically. The second case is undesirable because it negates our experiential feeling of being the centers of all cognitive processes (mercantile society), and makes our individual lives miserably alienated. Both are undesirable because conjointly they deny man. To believe that the spontaneous course of transformation of a society as a biological unity may lead to a non-oppressive system that does not negate the individual is, biologically, a delusion. Such a social system can only be obtained as an artifice of human creativity, and this by considering all individuals significant, through making the social system that they constitute in their coupling a non-hierarchical allopoietic system, designed to make their lives humanly desirable. Is this possible? My answer is yes, it can be done, but only by agreeing to continuously seek to generate a finite non-hierarchical society in a finite ecologically stable earth, by steps which do not deny the desired end. In other words, I think that such a society can be obtained by agreeing to continuously seek to generate:

- i) a society that continuously negates and destroys any political, economical or cultural institution for the subordination of man to man in any possible form;
- ii) a society that seeks to change its institutions following the changing material, aesthetic and spiritual ways in which the biological needs and cultural desires of all human beings are satisfied, because social institutions are instruments to be used by men to satisfy their needs and desires, and not entities to be maintained by them;

- iii) a society that continuously seeks to become non-hierarchical, because its members accept the possibility of error and recognize that anything that leads to an increased difference between the present human hierarchical relations and the desired non-hierarchical ones is a mistake;
- iv) a society whose members understand that they live on a finite earth, and that their biological existence is coupled to the ecological stability of this finite earth;
- v) a society whose members understand that the natural course of all plastic biological systems is towards the stabilization of the hierarchical relations that determine their unity, and that non-hierarchical society is an artificial biological system produced by man that can never be obtained as a stable system, but which must be continuously produced as an always regenerated approximation to that state. Furthermore, I think that such a society can only be obtained if the following operational conditions are fulfilled:
 - 1) Population stability, which is a necessary condition for an absolute accumulation of material well-being, uniformly distributed among all human beings, and for the possibility of agreeing on a common purpose that is not the individual accumulation of wealth and power, which by generating hierarchical relations intrinsically negates the possibility of a non-hierarchical society.
 - 2) A population size which is the minimal population that allows for an interesting and diversified life for everyone on an ecologically stable earth, and for a realtime access of every member of the society to the information, knowledge, and possibility of decision that its operation as a system continuously generated through the ethical decisions of its members requires.

If we indeed desire to generate such a non-hierarchical society, we must start from our present day societies and modify them in a manner that does not negate the desired end, even if we do not know which form it will adopt in terms of its changing institutions, for a non-hierarchical society cannot be obtained by processes that increase hierarchical relations. A system can only be destroyed by denying the relations that constitute it, and, conversely, a system can be generated only by implementing the relations that do constitute it. There is no other possibility. Therefore, for man to generate a new society he must generate new interpersonal relations, and to do so he must change his cognitive domain. Accordingly, only if men want to live in non-hierarchical society in which everybody has real-time access to an interesting and satisfactory life will they create it, otherwise they will not. However, it is not the historical circumstance in which we now live, nor the laws of nature (for economic laws are an arbitrary human creation), nor lack of sociological imagination that limits us in the effort of creating a non-hierarchical utopia, it is our reluctance to abandon our culturally learned and deeply cherished joy of forcing other human beings to accept our pretended superiority. This is why unending discussions about the means to obtain a given end betray the lack of commitment to obtain that end. An end always specifies means to obtain it that do not negate it, but no agreement about ends is possible between members of different social systems if they do not change their ethic so as to coincide in a meta-level of identity. Social change can only arise from ethical change, therefore, a social revolution is first of all a cultural revolution.

Two Remarks

- 1) The terms “structure” and “organization” are synonyms to the extent that both make reference to relations existing between components in a system. Yet, there are some connotational differences

between the two terms, which are linked to their different ethnological origin, and which are worthwhile emphasizing because they allude to two different aspects of the constitution of a system. “Structure” comes from the Latin word *struere*, a verb that means to build. Thus, in agreement with this origin, the word “structure” refers both to that which is built and to the way in which its particular components are put together while making it a whole. In other words, the term “structure” emphasizes the relations between the parts as well as the identity of the parts which constitute a whole. As a consequence, two systems have the same structure if they have equivalent relations between equivalent components. Accordingly, the structural analysis in a given phenomenological domain (culture, for example), attempts at the discovery of universals both in the components and in the relations between the components in different phenomena of the domain. The word organization has a different ethnological origin; it comes from the Greek word *ὄργανον* (*organon*), which means instrument, and makes reference to the function or role that a component has in the constitution of a whole. Accordingly, the word “organization”, as distinct from the word “structure”, emphasizes the relations that define a system as a unity (and thus determine its properties), with no reference to the nature of the components, which can be any at all, as long as they satisfy these relations. Therefore, two systems have the same organization if the relations that define them as unities are the same, regardless of how these relations are obtained, and, accordingly, two systems that have the same organization may have different structures. Also, since two systems are equivalent only if they have the same organization, it follows that if the organization of a system changes, the identity of the system changes and it becomes a different one, a new unity with different properties. Conversely, if the organization of a system stays invariant while its structure changes, the system remains the same and its identity stays unchanged. Strictly, then, the identity of a system is determined by its organization and remains unchanged as long as this remains unchanged, regardless of whether the system is static or dynamic and regardless of whether the structure of the system changes or not. In the context of this distinction between the two terms “structure” and “organization”, it is easy to see that there are two kinds of dynamic (mechanistic) systems: those whose organization remains invariant as long as the product they produce remains the same, the allopoietic systems; and those that are the product of their own operation and whose organization remains invariant as they produce themselves, the autopoietic systems. It is also apparent that the organization of a system defines it as a unity for any space, while its structure constitutes it as a concrete entity in the space of its components. Thus, living systems are autopoietic systems in the physical space (see *Cognitive Strategies*), and, as such, the turn-over of matter that they undergo continuously, and the change in structure that takes place in them as a result of development and learning occur without loss of identity in the physical space. It is interesting to note, however, that although we make these connotational distinctions in the use of the terms “structure” and “organization”, we are usually unaware of them and thus do not realize that the organization of a system is by necessity an invariant, and we talk about changes of organization without realizing that such changes imply a change of system. This is because as observers we operationally identify a system in the physical space by perceptual distinctions that arise from our interactions with its components, and not from our recognition of its organization, and, accordingly, consider the system the same while its components remain invariant, regardless of whether its organization changes or not. This confusion of structure with organization, however, is not a severe operational problem when dealing with living systems as unities because these, as autonomous systems, assert their identity through their autopoietic organization in the physical space and force us to recognize it as long as they are alive, even if they are mutilated. Yet, this confusion has obscured the understanding that a whole is a unity whose particular properties are generated by the way it is constituted and not by the properties of its components.

2) Although the nervous system is organized as a closed neuronal network, we can describe it as if it were an open system when we observe the organism in its interactions with the environment. For the following reasons this contradiction is only an apparent one:

- i) Every closed system can be made to appear open without altering its organization, and, therefore, without interfering with its operation, by a structural change that consists in cutting it at some point and replacing the direct connection between the two artificially generated ends by an intervening device that allows the continued operation of the system and the observation of the two artificial ends as if they were intrinsically disconnected. When this is done, although the organization of the system is not changed, the system appears open to the observer. This is what in fact happens when we observe the nervous system of an organism, and we concern ourselves only with the cut ends, because we stand in the environment that intervenes between the organisms effector and sensory surfaces without altering the relations that define the nervous system as a closed network. The changes of state that the nervous system undergoes as a neuronal network always arise as changes in the relations of activity of its constituting neurons, and always give origin to new relations of neuronal activity, whatever the environmental circumstances that allow for the closure of the system at the level of its effector and sensory surfaces. The fact that the changes of state of the nervous system are adequate to the environmental circumstances in which they take place (contribute to the continued autopoiesis of the organism) results from the coupling of the structure of the nervous system to the interactions of the organism, and has nothing to do with its closed or open organization as a neuronal network. If this were not the case, illusions, as modes of behavior that the observer considers inadequate for the environmental circumstances in which he sees them to take place, would not be possible. The changes of state of the nervous system are determined by its structure, and not by the features of the environment that only constitute historical determinants for the sequence of the occurrence of those changes and, through that, for the structural specification of the nervous system. Therefore, the purposefulness that the observer sees in the operation of the nervous system, and that seems to justify his treating it as an open system that gathers information from the environment, is an artifice arising from his position as an observer who sees the effector and sensory surfaces of the organism independently, and treats them as intrinsically disconnected, by neglecting the constitutive role of the environment as an intervening agent that connects them. Accordingly, descriptive terms such as “purpose” or “function” are inadequate for describing the organization and operation of the nervous system as a neuronal network, even though the structure of the nervous system is coupled to its successful operation. That the notion of the closed nervous system should apply to the nervous system of the observer himself does not create a contradiction. The descriptions that the observer makes are made in the domain of consensual observable behavior (linguistic domain), developed through a history of successful orienting interactions between two or more organisms (human beings in our case), and thus, are subject to the same artifice of observation. Furthermore, the general case is that any pair of dynamic (mechanistic) systems with invariant organization but with plastic structure coupled to the history of their successive states can develop, through their mutual interactions, a domain of coupled consensual conduct as a linguistic domain in which they can converse.
- ii) A problem is a question. A question is a perturbation that the questioned system must compensate for by generating a conduct that satisfies certain criteria specified in the same domain as the perturbation. Therefore, to solve a problem is to answer a question in the same domain in which it is asked. An allopoietic system solves a problem posed by an observer when it

changes its states in a manner that satisfies the criteria imposed by the observer through the formulation of his question. For autopoietic systems the problem solving situation is different only to the extent that in them all phenomena are phenomena of autopoiesis, and any question put to them is necessarily a question in that domain. This is so notwithstanding the fact that the observer can treat an autopoietic system as an allopoietic one, and thus define additional domains in which he can specify questions and their solution. These latter domains, however, exist only in parallel with the autopoietic domain of the questioned system, and only for the coupled system that this forms with the observer. Strictly, then, an autopoietic system solves a problem as a system if the changes that it undergoes as a result of the interactions that constitute the problem allow it to continue to operate as an autopoietic system: that is, without loss of identity. As a consequence, and by constitution, autopoietic systems always have solutions for the interactions (problems) that do not destroy them: they cannot but undergo homeostatic changes that compensate for the perturbations generated by the interactions, for otherwise they disintegrate and the problems prove unsolvable.

It is in this sense only that the nervous system, defined as a system both by its closedness and by its participation in the autopoiesis of the organism that it integrates, participates in the solution of the problems that the organism has to solve. For this to take place, however, it is not necessary that there should be a representation of the environment in the nervous system as an operant factor in the determination of behaviour. In fact, since the solution to a problem need have validity only for the organism that faces it, and not for the observer, a given change of state of the perturbed organism is a solution to a problem only if it allows the organism to maintain its identity. Since the changes of state of the organism (the nervous system included) are determined by its structure, and not by the environment, a representation, which is a relation established by the observer, cannot enter as a factor in the determination of the behaviour of the organism. However, if the observer treats the nervous system as an open system (open network) designed to operate upon an environment, he must view its structure as a representation of the environment in order to explain the adaptive behaviour of the organism, and not as a homeostatic system that maintains constant certain relations of neuronal activity that have become specified by the historical coupling of its structure to the autopoiesis of the organism. With such an approach the observer cannot do otherwise because he handles the nervous system in terms of design, and, hence, as isomorphic to his description of his own operation. Yet, to do this is as gross an error as to claim that a representation of a road is a causal factor in the operation of a running automobile. Therefore, notions of representation and of coding of information have validity only for describing the interactions of the observer with the observed organism when he considers the nervous system as an open system, and not for the characterization of its organization as a neuronal network. In other words, the observer, who sees the organism in its interactions with the environment, can treat the changes that the organism undergoes as representations of the circumstances of its interactions, and describe it in these terms, but by doing this he describes a system different from the one that the organism with its nervous system is.