Cognition

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(1978)

That we cognite seems to us self-evident. In the very process of doing what I am doing, cognition appears to me as my immediate experience. I perform an act of knowledge when I act in a manner that I describe as a manipulation or handling of the world in which I exist. The *cogito ergo sum* of Descartes grasps this and gives to the experience of knowledge a central role: the *cogito*, the act of cognition, is for Descartes the starting point. Or, in other words, cognition is a human property and no question arises about cognition as a phenomenon. This I wish to change. I wish to present the way in which I make cognition a problem, and how I answer the question, "What phenomenon is the phenomenon of cognition?".

The problem.

If cognition is considered a human *property* and, as such, a given constituent of ourselves, and if we accept this as a starting point, whether explicitly or implicitly, then our attention necessarily turns to questions related to the *use* of cognition. If we do otherwise and consider cognition as a phenomenon that results from, or is produced by, our biological being, then cognition can be made an empirical problem and we can turn our attention to the question, "What kind of biological phenomenon is the phenomenon of cognition?".

The latter is my approach. Accordingly, my purpose is to study cognition as a biological phenomenon; but in order to do so I must define cognition as a biological phenomenon *with the use of cognition*, or, at least, I must show *with the use of cognition* how the phenomenon of cognition arises in the operation of living systems.

The difficulty.

The view of cognition as an *unanalyzable* property with which human beings are endowed implies an *object* reality that is cognited by the knower. The act of cognition requires an agent and an object. From this perspective the universality of knowledge is trivial: there are objects to be cognited and their presence determines their knowability. Ignorance is, in principle, a fault of the knower. Yet, if cognition is considered an *analyzable* phenomenon that results from the biological operation of the living subject, then it is not necessarily the case that cognition should imply an *object* reality that is cognited by the knower. Whether this is the case or not, however, depends on how cognition as a biological phenomenon takes place; and then we must accept from the very beginning that the objectivity of knowledge must, until an answer is obtained, remain an open question. To do this is more difficult than it seems because one cannot but use cognition to analyze cognition, but if one does not do it the phenomenon of cognition cannot be explained.

If cognition does not imply an *object* reality, the universality of knowledge becomes a non-trivial act of social creativity. Ignorance is, in principle, not a fault of the knower but a social hitch.

The starting point.

Every approach to the question of cognition uses language as an instrument of discourse, communication, or analysis. We use language to uphold one view or to assail it, to support a proposition or to detract it. Language is the common element in any explanatory attempt. Language, however, can either be used as something given without questioning its fundaments or what it does, or it can be used as an instrument that is in itself open to analysis and that constitutes a central problem in the quest for the understanding of cognition as a biological phenomenon. This I propose to do. Language is my instrument, but at the same time my problem.

My starting point is our use of language: *Everything said is said by an observer to another observer that could be himself.* We are observers and living systems, and as living systems we are observers. Whatever applies to living systems applies to us. Therefore, my task is to use language to describe living systems and to show how they may develop a language and become observers that may make descriptions as we do, and in the process use cognition to analyze cognition. I shall proceed accordingly.

The phenomenon of cognition.

As observers we assert or evaluate cognition in a given domain through effective action or through successful behavior in that domain. We have no other way or criterion that does not prejudge the answer to the questions that I am considering. Therefore, effective action or successful behavior will be the phenomenon that I shall seek to explain. In other words, my question will be: "What takes place in living systems that they can operate effectively and successfully in a given domain, language included?"

This approach implies a fundamental departure from the questions nowadays usually asked about cognition. In fact, I am not asking about meaning, information or truth, but I am asking about mechanisms and processes; I am not asking about how we know or what we know, but I am asking about what takes place in knowing. I am changing, as will be seen, a semantic question into a structural question, and in order to proceed in this manner I must turn to consider living systems as systems and show how they operate. Yet, in doing this I shall first use language as an instrument given for descriptions and only later shall I consider its origin and participation in the phenomenon of cognition.

Basic concepts.

In my answer to the question, "What kind of systems are living systems and how do they operate?", I shall use the following concepts and notions:

i) *Explanation*: an intended reformulation or reproduction accepted by a beholder as a model of the system or phenomenon to be explained will be an explanation.

ii) *Unity* (or operational whole): an observer defines a unity by specifying the operations of distinction that separate a discrete entity from a background. The observer may thus distinguish a simple or a composite entity. If he distinguishes a unity as an "atom", as an entity without parts, he distinguishes a simple unity. If he distinguishes a unity as made of components, he distinguishes a composite unity. In principle, however, an observer may always treat an otherwise simple unity as a composite one and vice versa; all that he needs to do is to specify the proper operations of distinction.

iii) *Background*: When a unity is defined a background is necessarily also defined, and both unity and background are endowed with the properties that the operations of distinction that separate them specify.

iv) *Organization and structure*: Whenever I refer to the relations between components that define a composite unity as a unity of a particular class, I shall use the word *organization*. Whenever I refer to the actual components and actual relations that realize a particular composite unity as a concrete case of a particular class of unities, I shall use the word *structure*. From this follows: a) that only a composite unity has organization and structure, and that a simple unity only has properties; b) that the relations that constitute the organization of a composite unity are a subset of the relations that participate in its structure; c) that the class identity of a composite unity remains unchanged as long as its organization stays invariant; and d) that a composite unity can undergo structural changes without loss of class identity, and thus be structurally plastic.

v) *Space*: A space is defined by the properties of a unity as the domain in which it can be distinguished. Thus, a simple unity exists in the space defined by its properties, while a composite unity exists in the space defined by its components because it is through the properties of its components that it is distinguished. Nevertheless, a composite unity treated as a simple unity exists in the space that its properties as a simple unity define.

vi) *Structure-specified systems*: If all the structural changes that a system (a composite unity) may undergo are specified at any instance by its structure, the system is a structure-specified system. Or, in other words, if a structure-specified system undergoes an interaction with an independent entity, what happens to it is specified by its structure, not by the independent entity which in the interaction operates only as a triggering agent for the system's structural changes. Or, in yet other words, an independent entity that interacts with a structure-specified system only *selects* the structural change that, in the system, follows the interaction but does not specify it. Science, as the domain of statements validated by the scientific method, can only deal with structure-specified systems. Other systems would not be accessible to scientific description because in such cases the scientist would find himself in the same position as King Midas of Phrygia with the golden touch, specifying the structure of the systems that he wants to study with the touch of his analytical instruments.

If an interaction triggers in a structure-specified system a structural change that does not change its organization, the interacting agent operates only as a *perturbing* agent and the Interaction only as a *perturbation*. However, if the interaction triggers a structural change that changes the organization of the system so that its class identity changes, then the interaction is a destructive interaction and the interacting agent a destructive (or disintegrating) agent. A structure-specified system, therefore, has a structure-specified domain of perturbations as well as a structure-specified domain of disintegrations. Furthermore, the structure of a structure-specified system also specifies which configurations of the medium may perturb it and which may disintegrate it. In other words, structure-specified systems do not undergo "instructive" interaction.

The living system.

We cannot identify a living system unless we know what a living system is like, and to know what a living system is like means to explain it, that is, to be able to describe a system that, through its operation, may generate all the phenomena that a living system may generate. Therefore, what I propose to do is to characterize the kinds of system which in their operation are indistinguishable from known living systems, and claim that, given the proper historical contingencies, these systems will generate all biological phenomena:

There is a class of systems each member of which is defined as a composite unity (system), as a network of productions of components which: a) through their interactions recursively constitute and realize the network of productions that produced them; b) constitute the boundaries of the network as components that participate in its constitution and realization; and c) constitute and realize the network as a composite unity in the space in which they exist. Francisco Varela and I have called such systems "autopoietic systems", and their organization the "autopoietic organization". A living system is an autopoietic system in the physical space (cf. MATURANA/VARELA 1975).

I shall not present a full discussion of autopoiesis here as it can be found in several publications by Francisco VARELA and by myself (cf. MATURANA/VARELA 1975; MATURANA/VARELA/URIBE 1974; MATURANA 1970). I shall however, make, several remarks relevant to our present purpose.

i) Autopoietic systems are structure- specified systems: whatever structural change they undergo is specified by their structure. For this reason nothing is said in the characterization of autopoiesis about the lawfulness of the processes that realize it; this is implicit in the statement that the autopoietic network is constituted and realized as a composite unity in the space in which its components exist (i.e. in the space they define). Thus, living systems as autopoietic systems in the physical space satisfy the laws of physical processes, otherwise they disintegrate.

ii) In the operation of autopoietic systems everything is subordinated to their autopoiesis, if not, they disintegrate. The result is that autopoietic systems operate as homeostatic systems with respect to their organization, and that, while autopoietic, they can only undergo structural changes that do not interfere with their autopoiesis.

iii) An autopoietic system as a dynamic system is necessarily under continuous structural change. Yet, for every autopoietic system, at any moment, its present structure determines its domain of possible structural changes, and its organization defines the limits within which these may actually take place without it losing its class identity. Accordingly, as the structure of an autopoietic system changes during its autopoiesis its domain of possible structural changes without loss of class identity changes too.

iv) As is the case with composite unities in general, an autopoietic system treated as a simple unity exists in a space different from the space in which its components exist, and it also has properties as a unity determined by its organization, not by the properties of its components.

v) To an observer an autopoietic system appears as an integrated regulated homeostatic whole. Yet, the unity or wholeness that an observer sees in an autopoietic system as a result of its autopoiesis, is realized through the interplay (operation) of the properties of its components (that is, through relations of contiguity only) in a manner determined by these properties. Therefore, if the properties of some of the components of the autopoietic unity change because they themselves are composite unities and their structures change, then the manner of realization of the autopoiesis of the system may change too because the relations of contiguity that realize the autopoietic network may have changed. If this takes place as a result of the internal dynamics of the system in a manner that stabilizes certain relations of production, the observer may describe this stabilization as regulation or homeostasis. However, since the whole has no operational participation in the processes generated by its components, the phenomena of regulation or homeostasis "take place" only in a metadomain with respect to what takes place in the realization of the autopoietic network.

vi) Nothing is said in the characterization of autopoietic systems about the media in which they are realized, nor about the characteristics of the components that realize them. This is so because the properties of the components of an autopoietic system that do not participate in its autopoietic network can be any whatsoever as long as they do not interfere with it, and because the autopoietic system determines the medium in which it operates through its actual structure.

vii) Reproduction is not a constitutive feature of the autopoietic organization. Reproduction is logically and operationally secondary to the constitution of the unity to be reproduced, and, therefore, secondary to the autopoietic operation of an autopoietic system. Reproduction, however, is necessary for evolution.

viii) An autopoietic system, with respect to its states, operates as a closed system that only generates states in autopoiesis. Or, in other words, every state in an autopoietic system is a state in autopoiesis, if not, it is in the process of disintegration. However, with respect to its components an autopoietic system is open to the extent that their production implies an interchange with a medium.

ix) Biological phenomena are phenomena that arise in a domain defined by the operation of living systems. Thus, a given phenomenon is a biological phenomenon only if involves the autopoiesis of at least one living system. Or, in other words, phenomena which are produced with the participation of living systems but without involving them through the realization of their autopoiesis, are not biological phenomena. For example, the encounter of two organisms in courtship is a biological phenomenon, but their accidental collision is not. Also, the chemical reactions that take place in the autopoiesis of a cell are not biological phenomena, but those in digestion are.

The nervous system.

Anatomically the nervous system is composed of cellular elements of various kinds that, according to the view the describer holds, may or may not include sensory and effector components. In the following I shall not attempt a full anatomical characterization of the nervous system, but I shall call all its components *neurons*, including in the class of cellular elements connoted by this term typical nerve cells as well as sensory and effector elements which are anatomically quite different from these but which, as components of the nervous system, operate in a similar manner.

A network of interacting neurons in which each state of relative neuronal activity leads in a closed manner to another state of relative neuronal activity, is a nervous system. Or, in other words, a nervous system is a system organized as a closed network of interacting neurons in which every state on relative neuronal activity leads to another state of relative neuronal activity, and that, given the proper historical contingencies, can generate all the phenomena that in living systems are proper to their operation with a nervous system. This is both a characterization and a definition and deserves the following comments:

i) The nervous system operates as a *closed* system and as such generates only states of one kind, namely, states of relative activity between its component neurons (nerve cells and sensory and effector elements). The nervous system does not have input and output surfaces as features constitutive of its organization, and does not operate as a system generating input and output relations. Input and output surfaces are defined by the observer who opens the nervous system by specifying a perspective for his description of its operation in a medium. Accordingly, the sensory and effector surfaces that an observer sees in an organism do not constitute an exception to the operational closure of its nervous system. In fact, every change in activity at an effector surface of an organism leads to (triggers) a change of activity at a sensory surface of the same organism, and *vice versa*. The closure between effector surfaces and sensory surfaces is realized through what the observer sees as the environment, yet this environment is only a means for closure, and it is only as such that it participates in the operation of the nervous system as a system. The importance of the environment for the descriptions that the observer makes should not mislead us. The observer stands in his descriptions in the very path of closure of the nervous system, between the sensory and the effector surfaces of the organism, and from that perspective the nervous system appears to him as an open neuronal network. The same would happen to the observer if he could become miniaturized and stand in a synaptic cleft. He would then consider both the intercellular medium in the synaptic cleft and the organism as his environment, and the nervous system of the organism would appear to him as an open neuronal network in which the postsynaptic membrane constitutes the sensory surface and the presynaptic membrane the effector surface.

ii) I have not characterized neurons, yet I have referred to them as implying cells with properties that allow* *them to form and integrate a network in which they perturb each other in a localized manner, following paths of interactions specified by the architecture of the network, and according to a sequence determined by the relative course of their internal dynamics.

iii) As a component of a living system, a nervous system necessarily operates by generating relations of neuronal activity subservient to the autopoiesis of the living system which would otherwise disintegrate. Yet, it does so as a structure-specified system, generating relations of neuronal activity specified by its structure (architecture of the network and properties of its component neurons) which change if this structure changes. Accordingly, different organisms with different structures have different nervous systems (if they have them at all) which generate different sets of relations of neuronal activity, which themselves participate in a different manner in the realization of their respective autopoiesis. At the same time, a neuron, by being a multiconnected node in the closed neuronal network, may participate in the generation of numerous different relations of neuronal activity within the network. Whichever the case, the subordination of the operation of the nervous system to the autopoiesis of the living system that it integrates, results in the autopoiesis of the living system necessarily operating as a reference selector for any structural change that the nervous system may undergo, even if such changes are continual.

The medium.

A unity exists in a medium determined by its properties as the domain in which it operates as a unity. Anything that a unity may encounter as a unity is part of its medium. Anything from which a unity may become operationally cleaved through its operation as a unity, is part of its medium. Depending on the kind of unity an observer distinguishes, what he sees as parts or states of a unity may be included in its medium. The medium of a unity is always defined by the unity as the domain in which it operates as a unity, not by the observer. The observer specifies a unity by an operation which implies an organization in the distinguished unity if it is a composite one, but the operation of distinction does not characterize the implied organization. Under these circumstances it is the implied organization of the unity that defines its medium, not the operation of distinction performed by the observer. Therefore, when an observer distinguishes a unity he does not necessarily have access to the medium in which it operates as a unity, but he himself defines a domain in which he sees the unity as a separable entity. The domain in which an observer sees a unity as a separable entity I shall call the *environment* of the unity. Accordingly, the environment overlaps with the medium but is not necessarily included in it. In this case the medium of a unity may include features that the observer does not see as parts of the unity's environment, but which, to him, appear to be inside the boundaries of the unity, even though they are operationally necessarily outside them.

Cognition.

If whatever takes place in a living system is specified by its structure, and if a living system can only have states in autopoiesis because it otherwise disintegrates (and stops being a living system), then the phenomenon of cognition, which appears to an observer as effective behavior in a medium, is, in fact, the realization of the autopoiesis of the living system in that medium. For a living system, therefore, to live is to cognite, and its cognitive domain is as extensive as its domain of states in autopoiesis. The presence of a nervous system in an organism does not create the phenomenon of cognition but enlarges the cognitive domain of the organism by expanding its domain of possible states in autopoiesis. Under these circumstances, there are two basic questions to be answered in the study of the biology of cognition, namely: a) How and why is it possible that an organism has, at any moment, a structure that allows it to operate effectively in a given medium?; and b) How does the nervous system change the cognitive domain of the organism that possesses it in comparison to one that does not? The first question refers to the problem of structural change which I shall call *structural coupling*; the second question refers to the operation in a closed network of neuronal interactions under conditions of structural coupling which I shall call *operational recursion*.

i) *Structural coupling*: Any change in the relations between components with invariant properties in a composite unity I call a structural change of the first order; any change in the properties of the components of a composite unity I call a structural change of the second order. A composite unity whose structure can change without it losing its class identity, that is, without change in organization, is a structurally plastic system; any plastic structural change in a composite unity I call a change of state. Since a structure-specified system can only undergo changes of state specified by its structure, the domain of structural plasticity of a composite unity is determined by its structure, not by the medium in which it operates and is realized as a unity.

The medium can only perturb a structurally plastic system, triggering a change of state that it does not specify. Under these circumstances, the perturbations by the medium operate as selectors of the structural changes of the perturbed unity, and the sequence of perturbations that the medium provides in the history of interactions of a given unity, operates as a selector of the sequence, or path, of the structural changes that the unity follows in this history. The outcome of this is the establishment of a structural correspondence between the unity in question and the medium in which it operates, which, to the observer, appears as adaptation or structural coupling. The form of this structural coupling or adaptation in a given unity undergoing a particular sequence of perturbations is specified by the structure and organization of the (composite) unity which, respectively, determine the domain of possible structural changes of the unity and the limits that it cannot overstep without disintegration. In living systems these limits are determined by their autopoietic organization, which must remain invariant while they are alive; their structural coupling, therefore, necessarily results in the homeostatic stabilization of autopoiesis under the constraints of the structure through which, in each individual case, it is realized.

In general, then, whenever a structurally plastic composite unity undergoes perturbations, the outcome is structural coupling, in the space in which the composite unity operates (is) as a simple unity, to the structures of the medium that realize the unity's domain of perturbations. Since the result of structural coupling is the stabilization of the relations of the unity in its medium, what the observer sees, if the unity is a dynamic unity, is the fitting of the structure of the unity into a structure that allows it to operate effectively in the medium of coupling. This phenomenon occurs in living systems through two different processes that imply two different domains of variability for the operation of the selective interactions that they undergo in their medium in two different moments of their life histories:

i.i) *Phylogeny*: When the organization and structure of a composite unity are uniformely present throughout the whole system and no component is single or compartmentalized, a simple cleavage may separate two unities of the same kind with identical or different structures. This phenomenon is reproduction by division and takes place in living cells as well as in some other systems. Whenever sequential reproduction by division takes place, so that each composite unity produces other unities that can later reproduce, and the unities produced in each reproductive step have different structures, differential realization of the offspring takes place through their independent interactions and a phylogeny is established. The outcome of the establishment of a phylogeny is the structural coupling of the members of the phylogeny to the medium in which they operate as simple unities and in which the selection takes place. To an observer this phenomenon appears as evolution, as a history of structural transformation of sequentially produced composite unities of the same kind. In living systems this phenomenon occurs readily because the conservation of autopoiesis in each reproductive step allows in the same breath for the occurrence of structural variability.

i.ii) *Ontogeny*: The individual history of the structural transformation of a particular composite unity is its ontogeny. In a structure-specified composite unity, at any moment, the structure of the unity determines both the set, or matrix, of its possible changes of state and the set, or matrix, of the possible perturbations that it may accept. Accordingly any of the possible perturbations would trigger a change of state in the composite unity, which would result in a change in the matrix of the possible perturbations of the unity. Under these circumstances, a particular sequence of perturbations determines in a composite unity a particular sequence in its changes of matrices of possible perturbations. Consequently, those perturbations which actually take place are not determined by the structure of the composite unity but by the structure of the medium, and these perturbations, without specifying the structural changes of the composite unity, select the path of structural changes it will follow. The outcome of any such process is the ontogenic structural coupling of any structurally plastic composite unity to the medium in which it is realized. Therefore, what an observer sees as a result of ontogeny in any particular composite unity, is either effective operation in an environment, i.e. structural coupling, or disintegration. In living systems ontogenic structural coupling (or ontogenic adaptation) is peculiar because all that remains invariant during the ontogeny of any particular organism is its autopoiesis and the manner in which it is realized.

ii) *Operational recursion*: The phenomenon of structural coupling takes place in relation to any domain in which a structurally plastic composite unity is defined as a unity. Thus, the configuration of internal states of a composite unity (as an observer sees them) can also operate as part of the medium in which the composite unity exists as a simple unity, and when this takes place recursive structural coupling of the composite unity with its own states occurs. In principle, there is no other limitation for this to occur than the operational distinguishability of the internal states of the system by the operation of the system as a unity through its interactions. In living systems the closed organization of the nervous system is particularly suited for recursions of this kind. Accordingly, let us consider the nervous system from the perspective of its operation as a closed neuronal network:

ii.i) *Perception*: a nervous system operates as a closed neuronal network generating relations of relative neuronal activity specified by a structure selected along the phylogeny and the ontogeny of the organism which it integrates. All its dynamics of states is, accordingly, a continuous flow of changing relations of neuronal activities modulated through perturbations generated in the medium, which result in the production and stabilization of relations of neuronal activities subservient to the autopoiesis of the organism. From the perspective of the observer, the intersection of the domain of perturbations of the nervous system, which takes place operationally through the interactions of the organism with the latter's environment, constitutes the domain of perceptions of the organism. Furthermore, for the observer an organism appears to act upon the environment and to accommodate its behavior according to the features of the environment that he perceives. Yet, in their dynamics of states the organism and the nervous system only operate as closed systems, merely generating structure-specified states, as would be the case for a pilot in an instrumental flight. If the pilot had to fly and land under conditions of zero visibility, he would have to maintain the indicators of the instruments of the aircraft within specified limits or following a specified path of variations. When the pilot comes out of the aircraft after landing, his wife and friends may come to him saying: That was a wonderful flight and landing! We were terrified! Yet, the answer of the pilot may well be: What flight? What landing? I did not fly, I was only maintaining certain dials within specified readings. In fact, it was only for an external observer that there was a flight, and this is exactly what happens with an organism and its nervous system. An observer sees a particular behavior, courtship for example, but what takes place in the organism and its nervous system is not courtship but a particular path of changes of states in their dynamics of the closed system. Perception as a phenomenon pertains to the domain of descriptions defined by the observer.

ii.ii) *Recursion*: To write, to eat or to sustain a philosophical conversation are, from the perspective of the observer, very different actions in very different domains, but for the nervous system they are only different cases of a single kind of phenomenon, different paths of change of relations of neuronal activities subordinated to the autopoiesis of the organism, triggered by different perturbations arising in the medium. This has a fundamental consequence: although different relations or paths of change of relations of neuronal activities in the nervous system may be operationally distinguished in the domain of interactions of the organism through differential triggering, they are operationally distinguished in the dynamics of the nervous system through different relations or paths of change of relations of neuronal activities. Under these circumstances, what takes place in the operation of the nervous system is always the *same* kind of process: distinctions of relations of relative neuronal activities through relations of relative neuronal activities, and, potentially, so on recursively. Furthermore, in the same breath, through the coupling of the organism to its medium, the operation of the nervous system may result in what the observer sees as the operational recursion of distinctions in the domain of interactions of the organism.

ii.iii) *Representations*: From the perspective of the observer who considers an organism in a medium, the changes of state that the perturbations by the medium trigger in it, may constitute representations of the medium, and the reactions of the organism that he beholds as a result of these perturbations may constitute indications, or descriptions, of the circumstances that constitute these representations. The observer, therefore, may describe the organism or its nervous system as acting, in their internally closed dynamics, upon representations of the medium while generating descriptions of it. Thus, even though the organism and the nervous system do not operate upon representations because they are structure-specified operationally closed systems, an operational recursion of distinctions in the domain of interactions of the organism may, to an observer, appear to be a recursion in a domain of representations, as if the nervous system were making representations of representations.

Truth and falsity.

If cognition is the effective operation of a living system in a medium, and if this effective operation is the result in each individual of a history of phylogenic and ontogenic structural coupling, the question of how cognition takes place is, in principle, answered. In fact, organism and medium are operationally interdependent systems in their dynamics of states, each following its independent structural specification. Therefore, adequate behavior is, necessarily, possible only as the result of structural coupling, and an organism is either in structural coupling or in disintegration. Furthermore, that an organism should be in structural coupling is not surprising. An organism is never outside a history, and necessarily always finds itself in a particular state and position as a result of its previous states and positions. Consequently, if at a particular moment an organism is not structurally coupled to the medium either because the independent dynamics of states of the medium has resulted in a state of the medium to which the organism is not structurally coupled, or because a previous state of the organism has led to a new one which is not structurally coupled to the present state of the medium, then the organism disintegrates (its autopoiesis is lost). In addition, structural coupling is commutative between all organisms of the same class adapted to the same medium, and an interchange or an operational replacement can take place between them without loss of adaptation.

How the structural coupling is obtained, whether through phylogeny or ontogeny, or through operational recursion, is, of course, irrelevant. The enaction of both modes of behavior is equally structure-determined. Or, in other words, instinctive and learned behaviors do not differ in their structural determinations; they differ only in the history or origin of the structures that determine them. Thus, instinctive behavior is determined by structures established through phylogeny while learned behavior is determined by structures established through ontogeny. Furthermore, both modes of behavior are equally triggered by specific (internal or external) perturbations, regardless of the circumstances that generate them, and both instinctive and learned behaviors can take place under conditions that an observer would call inadequate.

If a dog takes a slipper to play with, an observer may claim that the dog does not know what the slipper is for. Similarly, a teacher who asks a student to measure the height of a tower with the use of an altimeter, may flunk the student if he uses the length of the altimeter to triangulate the tower and obtains the height of the tower through geometry and not through physics. The teacher may say that the student does not know physics. Yet, it is only with respect to the observer, in the first case, and with respect to the teacher, in the second, that the dog and the student are in error or lack knowledge. In fact, the dog and the student have behaved according to their respective structural determinations, but each has operated in a domain different from the one expected, and has defined with his behavior a different unity than the one offered and has handled it properly. The dog has defined a toy and the student a problem in geometry. Therefore, the dog's misuse and the student's mistake are "misuse" and "mistake" only in the domains defined by the observer and the teacher, and only with respect to their definitions of their respective referential situations. The behaviors of the dog and the student are, in themselves, flawless, and reveal in each case a structural coupling different from the one expected by the observer and the teacher. Truth and falsity exist only in a referential domain defined by an observer.

Consensual domains.

If two structurally plastic composite unities interact with each other and thus operate as selectors of their individual paths of structural change, a reciprocal structural coupling takes place. As a result the changes of state of one system trigger the changes of state of the other recursively, and a domain of coordinated conduct is established between the two mutually adapted systems. If this takes place between living systems during their ontogenies, a domain of coordinated behavior arises that is indistinguishable from a domain of consensus established between human beings. Accordingly, I shall call such a domain of coordinated behavior established between organisms as a result of their ontogenic reciprocal structural coupling, a *consensual domain* or domain of consensus.

For an observer who beholds two or more organisms operating in a consensual domain, the organisms appear to be operating with consensual representations and, therefore, for him a consensual domain operates as a linguistic domain in which the behaviors of the interacting organisms constitute consensual indications or descriptions of their domain of interactions. Moreover, if, once a consensual domain is established, the structural coupling continues in such a manner that the interactions within the consensual domain operate as selectors for further structural coupling within the domain, and if the participating organisms are structurally sufficiently plastic, then a recursion takes place in which the participating organisms make consensual distinctions of consensual distinctions. When this recursive consensual domain is established an observer sees a generative linguistic domain in which metadescriptions take place. A linguistic domain with such characteristics is a *language*, and to operate in it is, from the point of view of the observer, to operate in a domain of descriptions that permits recursive descriptions of descriptions.

At this stage the following comments are necessary:

i) From the point of view of the observer every behavior is action in some domain, and different kinds of behaviors differ in the domains in which the actions take place. Yet, in terms of what takes place in the nervous system every behavior is a particular configuration of relations of relative neuronal activities in a closed neuronal network. Accordingly, what would appear to an observer as different behaviors in different domains of structural coupling (whether in a domain of inert components or in a consensual domain) would be shown at the level of the nervous system to be but different instances of phenomena of the same kind.

ii) Every behavior can be seen by an observer as a description connoting the circumstances that elicit it. Thus, a consensual domain can be seen by an observer as a domain of descriptions in which ontogenically established descriptions operate as perturbations in a system of recurrent interactions between reciprocally structurally coupled organisms. Furthermore, a description can be seen as a distinction of that which it connotes, and a consensual description as a consensual distinction. From this point of view a recursion in a consensual domain is a description of descriptions. That this kind of recursion in a consensual domain should take place offers, of course, no intrinsic difficulty with respect to the operation of the nervous system as a closed neuronal network. For this same reason, however, a description is constitutively not a description of *anything*, but it is a behavior in a consensual domain in which the descriptions only connote operations within the domain of consensus.

The observer.

When a metadomain of descriptions (or distinctions) is generated in a linguistic domain, the observer is generated. Or, in other words, to operate in a metalinguistic domain making distinctions of distinctions is to be an observer. An observer, therefore, operates in a consensual domain and cannot exist outside it, and every statement that he makes is necessarily consensual. This has four basic implications:

i) A metalinguistic domain is a metadomain only from the point of view of the observer because it is only within the domain of consensual interactions and from the perspective of the history of this domain, that a distinction is a metadistinction (a distinction of distinctions). Otherwise a distinction and a metadistinction are both consensual operations. For this reason, and because of the operation of the nervous system as a closed neuronal network, once a metadomain of distinctions is operationally defined, a meta-metadomain of distinctions can be operationally defined, and so on recursively. Under these circumstances the limitation to infinite recursion is not in the nature of the process, but lies in the actual possibilities of structural plasticity and diversity of possible states of the nervous systems of the organisms that participate in the consensual domain. Therefore, an observer can, in principle, always define a metadescriptive domain with respect to his present circumstances and operate as if external to it.

ii) The operation of an organism in a consensual domain is, as all that takes place in a living system, necessarily subordinated to its autopoiesis. Thus, although the linguistic behavior is consensual, it cannot contradict the laws of the space that the components of the living systems define because the linguistic behavior of an organism is a manner of realizing the autopoiesis of the organism in that space. As a consequence, there is an intrinsic isomorphism in the relational consistency of the operation within a consensual domain and the relational consistency of the operation of an organism in its domain of autopoiesis.

iii) The operation of an observer is structurally specified. Semantic relations, relations of meaning, symbols, etc., do not participate in the operation of the observer as a living system. The observer, however, by specifying a metadomain of distinctions with respect to a ground domain of distinctions, defines relations of meaning, symbols, etc., as consensual relations of relations, in a metalinguistic domain. Semantic relations are not necessary for the establishment of a linguistic domain, but they arise from the recursive application of distinctions upon distinctions.

iv) An observer operates in two nonintersecting phenomenic domains. As a living system he operates in the domain of autopoiesis. As an observer proper, he operates in a consensual domain that only exists as a collective domain defined through the interactions of several (two or more) organisms.

General comments.

The observer and language.

The observer and language have been generated through the description (with the use of language) of living systems and their operation. However, in this process language has appeared as a contentless consensual behavior the validity of which is established only through its consistency within the domain of consensus. Yet, I have generated the observer by defining a metalinguistic domain from the point of view of which language has content, and I have shown that language arises only if there are at least two organisms that interact and generate a consensual domain. However, in this process language has appeared as a contentless consensual . . . Therefore, by assuming objectivity (objects to which linguistic descriptions refer) I have denied objectivity. What have I done? I have defined a network of descriptive relations which, if realized as objective relations, generates an observer who can only make contentless descriptions through his consistent behavior in a domain of consensus in which objectivity exists only as a relation defined in a metalinguistic domain.

Objectivity.

Objectivity, content to a description, is needed for epistemological reasons only when we speak about speaking. Then we are in a metadescriptive domain, and the logic of the metadescription requires a substratum for the described phenomena to take place. Yet, we cannot characterize that substratum which we need only for epistemological reasons. The actual operation of language, as an ontogenically established system of coordinated reciprocal triggering of behavior between organisms, is contentless. In order to describe an absolute object we must interact with it, but as we interact all that the said absolute object can do is to trigger in us changes of state specified by our structure. Therefore, the changes of state in ourselves that would constitute the description of the absolute object would not be specified by the absolute object which, since the description would only reflect us in an interaction, would vanish in the relative relations of consensuality. We move in the world like the pharmacologist who uses a biological probe and describes the various substances that interest him with the changes of state on his probe. However, it is we ourselves who are our own probes for the descriptions that we make, even when speaking of the pharmacologist's procedure. Thus, to describe the world in a domain of consensus whose only claim to validity is its subordination to our autopoiesis, we use our own changes of state in autopoiesis. Therefore, we cannot make any other ontological claim about the nature of the substratum which for epistemological reasons we need for the realization of the autopoiesis, than that its relational structure must be, in some way, isomorphic with the relational structure of the domain of descriptions.

Cognitive domains.

To cognite is to live, and to live is to cognite. We as observers exist in a domain of descriptions, and this domain as a consensual domain is a cognitive domain. In fact we operate in many different cognitive domains which constitute many different ways of realizing our autopoiesis. Furthermore, each cognitive domain constitutes a closed domain of relations or interactions defined by features of internal consistency specified in the structural coupling that determines it. Thus, in general, any system of adaptations, whether to the inert medium or to other living systems or to both, whether established through phylogeny (symbiosis, parasitism, particular modes of habitation) or through ontogeny (consensual domains, learned activities), constitutes cognitive domains. In particular, there are many different consensual descriptive domains that we describe in different manners, each determined by the procedure of generation of the statements that pertain to it. All these domains tend to be described by the observer in terms of "knowledge". Science, a political doctrine, a particular religion, and many, many other creations that appear as particular cultural systems, constitute such domains. Yet, we as observers can always define a metacognitive domain from the point of view of which we are external to them, and behold them. This we can do, of course, because in our nervous system everything takes place in the same phenomenic domain of closed relations of relative neuronal activities. However, by doing so, we can observe that in each cognitive domain we, and all living systems with us, operate as if in a domain of objective (absolute) reality whose relativity can only be asserted if we step out and define a metacognitive domain with respect to it.

Determinism and predictability.

Living systems are deterministic systems, they are structure-specified unities. Furthermore, as scientists we can only deal with structure-specified systems; this is a feature of the scientific cognitive domain as specified by the scientific method. The fact, however, that as scientists we can only deal with deterministic systems, does not mean that we can always predict their changes of state. Determinism is a feature that the observer as a scientist must claim because he deals with structure-specified systems (otherwise he could not make explanatory models) and as such it is an epistemological necessity. But a prediction is a computation in a system in one domain (a model) claimed to be isomorphic to a system in another domain where the observation of the predicted event will take place. Therefore, whether a prediction is fulfilled or not is always a function of the relations that the observer establishes between the two domains, and does not depend independently on any of the systems involved. Therefore, any ontological claim of objective indeterminism based on scientific analysis is necessarily at fault. Finally, predictability does not constitute a proof of objectivity, it only constitutes a proof of an isomorphism between the relational structures of two cognitive domains. The effectiveness in the manipulation of the environment that the success of the experimental sciences shows is therefore not surprising. In fact, it is a necessary outcome of the basic ultimate reference of our scientific statements (as behaviors in a consensual domain), through the realization of our autopoiesis in a consensual domain, to the space (the physical space) which we define as autopoietic systems.

Creativity and freedom.

We are deterministic systems. Creativity and novelty, then, are not features of our operation as autopoietic systems, we assert them as observers. They are, therefore, features of the consensual domains in which we operate as such. If we undergo an interaction not specified in the consensual domain in which we operate, we undergo a structural change (of first or second order) not determined by the structural coupling of the consensual domain, and a new behavior appears with respect to the behaviors proper to the consensual domain. Under these circumstances we as participating organisms have operated as structure-specified systems, but an observer has seen a novel behavior that he could not have predicted from the determination of the consensual domain. Such interactions can take place only because the medium and the organisms operate in their interactions as independent systems, each determined in its dynamics of states by its own structural specification. Novelty and creativity in living systems, therefore, are always the result of their interactions outside their domains of structural coupling, and take place as such only for the beholder that would have predicted otherwise. It follows that structural coupling necessarily results in a reduction of creativity and novelty, and that the formation of a cognitive domain consists in the reduction of novelty and creativity in that domain. We as observers, however, have one escape from the ultimate reduction of creativity that would be the necessary outcome of our progressive structural couplings. This is the very condition that makes us observers, namely our operation in a linguistic domain that allows us to generate a metadomain of descriptions. In fact, this is our only (and the only worthwhile) claim to freedom. We can in principle always be observers of our circumstances. For this to take place all that we need to do is to extend our interactions beyond our domains of structural coupling (consensual and otherwise). This is also the reason why the ultimate aim of every totalitarian political system is prudish social morality, i.e. the total specification of the experiences of the human beings under its sway. This, however, is not easy to obtain because it would require the destruction of the observer and, with it, of language.

Ethics and love.

A human behavior that affects the lives of other human beings is ethical conduct. All our behaviors within the consensual domains that we establish with other human beings are, therefore, behaviors with ethical significance. This we cannot escape. Yet, since we, as observers, exist only in a linguistic domain, that is, in a consensual domain with other human beings, the denial of the ethical significance of our behavior as observers would necessarily lead to our alienation.

As living systems we exist in complete loneliness within the closure of our individual autopoiesis. It is only through the worlds that we create with others through consensual domains that we acquire an existence that, without breaking this our fundamental loneliness, transcends it. Furthermore, it is only through this that we can define a domain of self-knowledge through self-descriptions in a metadescriptive domain in which we are objects to our descriptions. For that we need the other person because we can only see ourselves in the reflections of a consensual domain. We cannot see ourselves if we do not learn to see ourselves in our interactions with others and, by seeing the others as reflections of ourselves, see ourselves as reflections of the others. Fortunately we as living systems spontaneously generate consensual domains with other living systems in general, and with other human beings in particular. We map upon them and enjoy their company. Love is not blind because it does not negate, love accepts, and, therefore, is visionary.

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