

Brain, language and the origin of human mental functions

HUMBERTO MATURANA, JORGE MPODOZIS*
and JUAN CARLOS LETELIER

Departamento de Biología, Facultad de Ciencias,
Universidad de Chile, Santiago, Chile

We propose that to understand the biological and neurophysiological processes that give rise to human mental phenomena it is necessary to consider them as behavioral relational phenomena. In particular, we propose that: a) these phenomena take place in the relational manner of living that human language constitutes, and b) that they arise as recursive operations in such behavioral domain. Accordingly, we maintain that these phenomena do not take place in the brain, nor are they the result of a unique operation of the human brain, but arise with the participation of the brain as it generates the behavioral relational dynamics that constitutes language.

Key terms: brain, language, mind, nervous system, self-consciousness.

INTRODUCTION

Our purpose in this essay is to propose our views about what we consider to be human mental functions, and to reflect about what we think is the participation of the nervous system in generating them. Let us begin presenting the problem.

In our Western tradition we frequently speak of mind phenomena as of objects. Thus, questions such as "where is the mind located in the brain?" or "how do the mind and the body interact?" seem adequate questions. And if we do not consider mind or consciousness as entities, but as processes, we treat them with a reductionistic view, as if a particular manner of operation of the brain were to constitute them, and then we look in the brain for some unique neurophysiological process. Or, in the extreme case, we declare that mind and mental functions are unimportant epiphenomena, and that the materiality of neurophysiology is all that counts when dealing with the nervous system (for a revision, see Crick, 1994).

We think differently. We think that the so called mental processes are behavioral relational phenomena, that self-consciousness is a manner of living with others in the relational domain constituted by "linguaging", and as such arises with the participation of the nervous system, as it participates in the generation of the behavioral relational dynamics organism-medium. Moreover, we think that self-consciousness and mental processes are relational processes that modulate the structural dynamics of the organism and the nervous system precisely through their manner of recurrence as relational processes. In these circumstances, to answer the questions about the participation of the nervous system in the generation of self-consciousness and mental processes, it is necessary to adopt a different view than the usual neurophysiological one. To attain this end, we shall first present our epistemological and biological fundamentals, after that we shall speak about the nervous system and its operations as components of the living systems and, finally, we shall present our

* **Correspondence to:** Dr Jorge Mpodozis, Departamento de Biología, Facultad de Ciencias, Universidad de Chile, Casilla 653, Santiago, Chile. Fax: (56-2) 271-2983. E-mail: epistemo@abello.seci.uchile.cl.

view about the human domain of existence, showing how mental phenomena arise.

I. EPISTEMOLOGICAL FUNDAMENTS

Any attempt to explain and understand living systems and all that happens in relation to them, requires the full explicitness of the notions that one thinks give validity to the explanation being proposed. It is with this purpose that we shall say a few words about scientific explanations and about systems and systemic phenomena, before proposing our explanation of the human mental phenomena.

1. What we do as scientists is to explain our experience in the implicit understanding that experience is which we distinguish as happening to us as observers in our living. In doing that, we use our experience and the coherence of our experience to propose generative mechanisms for our experience in the context of the satisfaction of the criterion of validation of scientific explanations (Maturana, 1990). Even when we speak of phenomena as if we were talking about something independent from us that appears in our perceptual space, we are distinguishing experience that happen to us in our living. We believe that the fundamental difficulty that we face in the process of explaining mind and self-consciousness as phenomena, is to fully accept that they are that: phenomena, experience. The claims that they are entities, or reflections of the operation of some kind of entity inside or outside the brain, or epiphenomena, or nothing at all, are manners of explaining the experience that we connote when speaking of self-consciousness and mind.

2. A scientific explanation consists in the proposition of a generative mechanism, that is, a mechanism or process that if allowed to operate gives rise, as a result of its operation, to the phenomena that one wants to explain (Maturana, 1990). Scientific explanations do not constitute phenomenal reductions, that is, they do not consist in expressing the phenomena of one domain in terms of the phenomena of another domain which is considered more basic. Quite on the contrary, a scientific explanation consists in showing a generative relation between phenomenal

domains that do not intersect, and does so by showing how the phenomena in one domain result as a consequence of the processes that take place in the other phenomenal domain. It is for this reason that an explanation does not replace the phenomenon explained, and it is nonsensical to ask about the interaction between the result and the process that gives origin to it, as would be the case if one were to ask about the mind and body interactions after showing that the mind is a result of the operation of the body.

3. A system is a collection of elements that interact and relate with each other in such a way that the interactions that any of those elements have, and the results of these interactions, depend upon its relations with the others. As a result of the continuous operation of a system, an interactional boundary arises between the system elements and all the others with which they may interact and relate. The elements that do not belong to a system but with which the elements of the system may interact and relate, form an operational medium in which the system exists as a composite unity. As a system arises, a new phenomenal domain appears as the domain of relations in which the new system operates as a totality. The properties or features of the new domain can not be deduced from, nor reduced to, the features of the domain that give origin to it. The new domain is, with respect to the source domain, intrinsically new.

4. Due to this manner of constitution, a system is a structure-determined composite entity, and it is possible to distinguish in it an organization and a structure. The relations between components that define the class identity of a system constitute its organization, and all the components plus all the relations between them that realize a system as a particular system of a particular class, constitute its structure. In these circumstances, the organization of a system is realized in its structure. Moreover, since the organization of a system defines its class identity, a system remains the same in terms of its kind only as long as its organization is conserved. At the same time, since the structure of a system has more dimensions than its organization, the structure of a system can change with or without conservation of the

organization of the system. As a result, if the organization of a system is conserved while its structure changes, the system remains the same; and conversely, if the organization of a system is not conserved during its structural changes, it disintegrates or disappears and something else appears instead. We call the structural changes that occur in a system with conservation of organization, changes of state, and those that occur with loss of organization, disintegrations.

5. As a structure-determined composite entity, a system is such that all that happens in it and to it is determined in its structure. Nothing external to a structure determined system (SDS) can specify what happens in it. The structural changes that an SDS undergoes arise either as a result of its internal dynamics, or triggered through the encounter of the properties of the elements that compose it with the elements that compose the medium. The external elements that impinge upon an SDS do not determine the structural changes that arise in it, they only trigger them. We call perturbations the interactions that trigger in a SDS a change of state, and destructive interactions those interactions that trigger its disintegration. The structure of an SDS determines what structural configuration of the medium it may encounter in an interaction, and then what it encounter as a perturbation or as a destructive interaction. The medium, if we want to look at the interactions from its perspective, only determines the occasion in which the interactions take place. We call structural drift the course followed by the structural changes of an SDS while its interactions in a medium are mere perturbations. The fundamental consequence of the structural dynamics of an SDS in structural drift, is that the system and its circumstances change together congruently, and an SDS remains always in congruence with its circumstances, and its circumstances remain always in congruence with it while it conserves its organization. Finally, as we speak of structural determinism and operate with the coherence of structural determinism in our explanations, we do not invoke a transcendental ontological notion or principle; the notion of structural determinism is an abstraction of the experiential coherence of the observer.

6. When a repeating circular process becomes coupled with a linear one that displaces the circumstances of the repetition, the repetition of the circular process becomes a recursion, and a new phenomenal dimension appears. Thus, for example, when the circular movement of the wheels of a car is coupled with the linear displacement of the ground, the circular movements of the wheels becomes recursive and the phenomenon of movement appears. Recursion is a form of generating new phenomenal domains in the interactions of SDSs that is not seen unless one attends to the relations of coupling of a circular and a linear process. In biological systems, recursion is a fundamental dynamics, because of the circular character of biological processes and the linear character of the relations between a living system and its changing medium.

II. BIOLOGICAL FUNDAMENTS

Our purpose is to explain and understand the participation of the nervous system in the generation of mind and self-consciousness phenomena in the human life. Accordingly, we must reflect on the biological phenomena and biological understanding that serve as the foundations of our proposition. And since we are inviting a new manner of considering the matter of mind and self-consciousness, we will be explicit about what we think in relation to the constitution and the operation of living systems. 1. Living systems are dynamic molecular SDS, organized as closed networks of molecular interactions that produce the same kinds of molecules that produced them, and specify dynamically at every instant the extension and boundaries of the network. Such a network is closed in terms of its dynamics of states of molecular productions, but is open to the flow of matter and energy through it. Maturana (1970) and Maturana and Varela (1973) have shown that those statements constitute a complete characterization of living systems as molecular systems, specifying their conditions of existence and autonomy. Maturana and Varela (1973) called this organization the *autopoietic organization*, and claim that living systems are molecular autopoietic systems.

According to this notion, cells are first order autopoietic systems and multicellular systems are second order autopoietic systems. A multicellular living system is accomplished through the autopoiesis of its cellular components and, through its own fulfillment as a multicellular totality, makes possible the autopoiesis of them. As autopoietic systems, living systems are in a continuous structural change, both as a result of their intrinsic internal dynamics, and as a result of the changes triggered in them in the course of their recurrent interactions in a medium. A living system lives as long as its structural changes take place in the conservation of its first or second order autopoietic organization.

2. A living system, as a composite cellular and molecular system, exists in two domains: a) in the domain in which its components realize it as a first or second order autopoietic entity, namely in the metabolic or physiological domain, and b) in the domain in which it interacts and relates with the medium that contains it as a totality, namely in the relational or behavioral domain. The phenomena of the metabolic or physiological domain take place in the structural dynamics of the components of the living system, and are totally contained in it. Contrariwise, the phenomena of the behavioral domain arise in the relation living system/medium, and are not determined by the living system or the medium alone. That is, the behavior of a living system is not something that the living system does, nor something that the medium specifies of its own, the behavior arises and takes place in the relation living system/medium (Maturana and Mpodozis, 1987, 1992). There are, of course, as many different kinds of physiological and behavioral domains as there are different kinds of living systems with different structures and different manners of living.

3. The two phenomenal domains in which a living system exists cannot be reduced to each other, because –as it was exposed in I.2 and I.3– they take place in non intersecting phenomenal domains, and then, any attempt to explain the phenomena of one domain in terms of the other, is inadequate. There is, however, a recursive dynamic generative relation between them through the structural

changes that living system and medium trigger in each other in the course of their interactions: A) as living system and medium interact, they trigger in each other structural changes; B) the structural changes triggered in the living system result in a change in the manner in which the living system encounters the medium in the next interaction, and the same happens with the medium with respect to the living system; C) as a result of what happens in moments A and B, the relation between living system and medium changes, and the structural changes that living system and medium trigger in each other in their next encounter change too; and D) the process indicated in points A, B and C, repeats recursively in a manner that appears to an observer both as if the behavior modulated the physiology, and as if the physiology modulated the behavior, even though they take place in phenomenal domains that do not intersect.

4. This recursive mutual modulation of behavior and structure in the interactions between living system and medium have two fundamental results. The first is that the structure of the living system and the structure of the medium change together, and in congruence, both in ontogeny and phylogeny. The second is that all living systems at every moment of their ontogenetic and phylogenetic histories necessarily have dynamic structures that are adequate for the generation of a behavior adequate for the dynamic medium in which they are alive, or they die. We say in relation to this, that each living system exists (operates) at any moment in structural coupling with the biosphere as a broad domain of existence, and that it does so as a continuously arising consequence of the particular phylogenic and ontogenic history to which each of them belongs.

5. The ontogeny of a living system from its inception to its death takes place as an epigenetic process that results from a systemic dynamics involving a recursive interplay of physiological and relational phenomena, in the manner indicated above. So, a living system is a systemic entity that: exists as a living being in the physiological domain of its bodyhood and realizes its manner of living in its domain of relations in recurrent interactions with the medium, through a

dynamic interplay of its body dynamics and its behavior. Accordingly, what reproduces when a particular living system reproduces, is a particular systemic entity whose realization takes place in the continuous dynamic interplay of a particular bodyhood and a particular configuration of dynamic circumstances that have arisen in the medium along the phylogenetic history of the reproducing living system. At the same time, what is organically passed to the next generation through reproduction is an initial structural configuration that makes possible the epigenetic realization of a particular manner of living that entails the systemic conservation of a particular bodyhood and bodyhood dynamics if it is placed in the proper circumstances of the medium. Inheritance, then, as it consists in the reproductive conservation of an epigenetic manner of living, is a systemic process, and as such is not determined by any particular set of molecular or cellular components, however essential these may be for its occurrence (Maturana and Mpodozis, 1992).

6. When the realization of a manner of living begins to be systemically conserved generation after generation through reproduction, a lineage is constituted and established. Such lineage will last as long as that manner of living remains conserved. Moreover, as a lineage is constituted and conserved in the systemic conservation of the manner of living that defines it, all the features of the physiological domain, as well as all the features of the relational domain of the living systems that realize the lineage, become free to change around that which is conserved, in a way in which both living systems and medium remain in dynamic reciprocal operational congruence (Maturana and Mpodozis 1992). In these circumstances, the differences in bodyhood and behavior that different individual living systems members of a lineage exhibit at any moment of the history of the lineage, are the results of variations of the manner of realization of the manner of living that defines the lineage. In these circumstances a new lineage arises when some variation in the realization of a particular manner of living becomes part of the manner of living henceforth systemically conserved generation after generation (Maturana and Mpodozis, 1992).

7. In summary, all that we have said so far shows how living systems exist and cannot but exist in structural coupling, that is, in dynamic congruence with the medium. At the same time, all that we have said so far indicates that the medium as a relational domain, and regardless of how it is composed, necessarily changes congruently with the organisms that it contains, so that the organisms remain in operational congruence with it, or die. This condition has two fundamental consequences relevant to our task. One consequence is that all living systems and their respective circumstances of living, form a historical network in which each living system becomes a close or distant part of the medium or domain of existence of all the others. This is what we connote when we speak of the biosphere. The other consequence is that every living system has a bodyhood, a body architecture and a physiological dynamics adequate to its manner of living and to the changing circumstances of its realization. As a result of this situation, it is not necessary to explain *de novo* the present behavioral congruence of any living system with its circumstances and one can use that congruence as a starting point.

III. NERVOUS SYSTEM AND BEHAVIOR

Biologists usually speak as if the behavior that we observe, as we observe an organism in its interactions and relations were something that the organism does. Thus, as we see an animal walking, we do not usually realize that the walking results in the encounters organism-medium, and that all that the organism does as it walks is to perform sensory/effector correlations. This is apparent when ethologists speak of vacuum activities, or vacuum discharges, to describe an organism performing what looks like an out of place behavior (McFarland, 1993). As we consider that behavior takes place in the relation organism-medium and is not something that the organism does, what one has to explain is how does the nervous system participate in the generation of the sensory/effector correlations of the organism, and how is it that it does so in a way that the organism remains in a dynamic congruence with a changing

medium while it lives. In what follows we will propose our views about these matters.

1. The nervous system is a closed network of synaptically interacting active cellular components, that we shall call neural elements (nerve, muscle and secretor cells). The nervous system operates as a closed network of changing relations of activity between its neuronal components: any change in the relations of activity holding between some components of the network leads to further changes in the relations of activity holding between other components of it, and so on recursively, in a potentially never ending dynamics (Maturana 1969; Maturana and Varela, 1980; Maturana and Mpodozis, 1987). The course that follows these changes of relations of activity is at every moment determined by the state of the activity of the neuronal elements of network at that moment. At the same time, the state of activity of the cells that compose the neuronal network is at any moment the result of the state of their dynamic structure at that moment, and change as this change through their synaptic operations within the network and through their structural intersection (by means of synaptic, trophic, hormonal and transducer-like effects; see below) with other components of the network and the organism.

2. The nervous system structurally intersects the organism at several body areas that constitute the latter's internal and external sensory and effector surfaces. The external surfaces constitute the interfaces by which the organism encounters the medium. The internal surfaces constitute the interfaces by which the nervous system, as a component of the organism, encounters the physiological dynamics of the organism. Accordingly, the neural components of the sensory and effector areas have a double identity and a double operation. First, as elements of the nervous system they operate in the closed dynamics of changing relations of activities of the nervous system. Second, as parts of the organism they operate as components of its surfaces of internal and external interactions.

3. As a consequence of this structural intersection, the nervous system through its operations as a closed network of changing relations of activity between its neuronal

components, continuously generates in the organism sensory/effector correlations that modulate both the flow of its interactions in the medium, and the flow of its physiological dynamics. The behavior of the organism arises in the dynamic encounter organism-medium through the sensory/effector correlations of the organism and the structural dynamics of the medium. Therefore, the nervous system participates in the generation of the behavior of the organism through the sensory/effector correlations to which it gives rise at any moment, according to its structure at that moment.

4. The nervous system does not interact with the medium, it is the organism that does so through the operation of its effector and sensory surfaces. It is the structure of the organism as a whole that determines which sensory/effector correlations are possible for it, not the dynamics of the nervous system alone. All that the nervous system can do as it intersects with the external and internal sensory and effector surfaces of the organism, is trigger in these structural changes that result in one or another of the sensory/effector correlations that are possible for the organism according to its present structural dynamics (Maturana and Mpodozis, 1987). Furthermore, the structural changes triggered in the external sensors both, as components of the sensory surfaces of the organism and as neuronal elements, are determined in their structure and not by the circumstances of the interaction that trigger them. In these circumstances, as the organism interacts with its medium, its nervous system undergoes changes in the flow of its synaptic operations that are contingent to the interactions organism-medium, but that are determined by the structure of the nervous system, and not by the characteristics of the medium. As a result, the nervous system does not and cannot operate with representations of the medium, and what it does, it does according to its structure at any moment.

5. The structure of the neural cells is in continuous change, both as a consequence of its own autopoietic dynamics and as a consequence of its participation as components of the nervous system and the organism. Some of these structural changes are specially relevant, because they entail long term

changes in the synaptic dynamics of the neural cells. As far as we know, these structural changes happen in four ways: A) Through the so called "transducer effects", that are structural changes triggered at the neural component of the sensors through the encounters of the organism with the medium. These structural changes have been traditionally called "transducer effects", through thinking that what is significant in them is an energy transfer. According to us, what is significant is that these structural changes are those that couple the activity of the nervous system to the flow of interactions of the organism or to its internal physiological dynamics. B) Through synaptic effects, which are structural changes of different time constants triggered in the neural cells by the actual flow of synaptic interactions. C) Through trophic effects, which are structural changes that arise in the neural cells triggered by substances of neural origin that are produced by processes orthogonal to the synaptic flow (because they involve molecules and cellular interactions which are not proper to the synaptic operation of the nervous system) but contingent to it. D) Through hormonal effects, which are structural changes triggered in the neural cells by substances produced in the organism through physiological processes that do not involve directly the operation of the nervous system.

6. If we consider together points 3, 4, 5 and 6, it becomes clear that although the medium does not specify what happens in the nervous system, during the ontogeny of an organism, the structure of its nervous system (the neural connectivity, the cellular dynamics of production of neurohumors, membrane receptors, molecular channels, etc) changes in a manner contingent to the flow of interactions of the organism in the medium, to the internal physiological and developmental history of the organism, and to the flow of the operation of the nervous system as a component of the organism.

7. The structure of an organism and the structure of its nervous system are structures that have arisen in an evolutionary history of transgenerational conservation of a manner of living (see II.5). Such history is in fact an epigenetic relational dynamic organism-medium, that consists of the realization of

the living of the organism. For these reasons, the structure of the nervous system, as it arises through its development in any particular organism, and the closed dynamics of changing relation of activity that it generates during its development, cannot but be adequate for the generation of the particular interactional behavioral dynamics that the manner of living of the organism entails.

8. The course of the structural changes that the nervous system undergoes through the life history of the organism that it integrates, is de facto constrained by two conditions: A) by the structure that the nervous system has as a component of an organism that belongs to a particular lineage, as indicated in III.7; and B) by the actual contingencies that occur in the living of the organism, through the processes described in III.5 and III.6. As a consequence of this, every organism has at every moment a nervous system adequate to the generation of the sensory/effector correlations proper to its particular history of realization of its manner of living, precisely because the structure of its nervous system is the present of a history of structural changes contingent to the course of the phylogenetic and ontogenetic history of this organism. In other words, every animal always has a nervous system proper to its biological identity, as this consists and is realized in the relational space of its manner of living. That means, for instance, that the brain of a dog becomes a "dogging" brain in the course of the realization of the dog's manner of living, and becomes a particular "dogging" brain in the course of the realization of a particular dog life.

9. The operations of the nervous system as a closed network of changing relations of activities, take place as an interconnected dynamics of circular processes. As the circular dynamics of the operation of the nervous system become coupled to the lineal flow of the behavior of the organism through the structural intersection of the nervous system and the organism, the circular operations of the nervous system become recursive with respect to the flow of the behavior of the organism that it integrates (see section I.6). As a result, a new dimension appears in the domain of the behavior of the organism, and the organism begins to behave as if it were

operating with abstractions or representations of its domain of interactions, by acting as if it were using such abstractions or representations to generate a new behavior which appears as a reflection on the basic one. An example would be when a dog makes a detour to reach a place when faced with an obstacle in a non previously lived particular situation. But, of course, for the internal recursion to happen, the association of the linear behavior and the circular dynamics of the nervous system cannot be occasional, must be repetitive as a feature of the living of the animal. In these circumstances, the complexity of the new dimensions that appears as the operation of the nervous system becomes recursive, is related to the manner of living of the organisms involved, and is not a feature of the operation of their nervous systems. Accordingly, as different animals live differently, the coupling of the circular dynamics of the nervous system with the linear flow of the behavior of different animals will give rise through recursion to different new behavioral domains. And this is a general phenomenon: the complexity, richness and meaning of the behavior of an organism is not a feature of the operations of its nervous system, but of the historical circumstances of its living.

10. It follows from the previous points that a nervous system operates with different dimensions than those with which the observer sees the organism to operate in the relational and interactional space in which it exists as a totality. The observer sees the organism in its relational and interactional space interacting and relating with entities of different kinds or (in the case of social animals) with relations and symbols as if these were also entities. The nervous system in its internal dynamics, however, operates as a closed network of changing relations of activities between its component elements, and not with the kinds of entities that arise in the domain of relations and interactions of the organism.

11. In summary, the nervous system as a component of a living system, is constituted as a closed network of neuronal elements that operates as a closed recursive network of changing relations of activities (between the neuronal components) in which

every change of relation of activity recursively leads to other changes of relations of activities in it. The nervous system as such a neuronal system intersects with the organism at its sensory and effector surfaces, and its closed operation gives rise to sensory/effector correlations in the organism that in the interactions of the organism in its medium, constitute its behavior. The nervous system does not operate making representations of the medium in which the living system that it integrates exists. Nevertheless, it has a plastic structure that changes following the contingencies of the living system while this system maintains its autopoietic organization in a medium. As a result of these structural changes, the closed operation of the nervous system continuously gives rise to configurations of sensory/effector correlations in the organism that realize its living in its changing medium, until this congruence is lost and the organism dies.

IV. BRAIN, MENTAL FUNCTIONS AND THE DOMAIN OF HUMAN EXISTENCE

We exist as human beings with a particular bodyhood and a particular manner of living; furthermore, our bodyhood and manner of living are in perfect congruence: our bodies are adequate for doing what we do, and we do things that fit the operation of our bodies. We do not have to think, plan or design the operation of our bodies as we move, talk, eat, have sexual relations; we do not have to do what we do in our nervous system as we talk, think, have joy, feel pain, or solve a problem. Like every other animal, we are as we are as a result of the phylogenic and ontogenic history to which we belong as human beings and as individuals. And like in every other animal, our nervous system operates as a plastic closed network of changing relations of synaptic activities, giving rise recursively in us to sensory/effector correlations adequate to the realization of our manner of living. In these circumstances, all that is left for us to do is to reflect about the particularities of our human manner of living as self-conscious beings, show the domain in which these particular human phenomena take place, and through that show how the nervous system participate in generating

them. This is what we shall do in the followings points.

1. We human beings are “languaging” beings and our humanness takes place in language. Language as a biological phenomenon is a manner of operating in consensual coordinations of consensual coordinations of behavior (Maturana, 1978). As such, language takes place in the relational domain as a manner of living, and not in the brain as a phenomenon of the operational or structural dynamics of the nervous system. The nervous system is, of course, necessary for the generation of the sensory/effector correlations that result in the flow of consensual coordinations of consensual coordinations of behavior that “languaging” is. Therefore, and according to what we have said above, we human beings exist as systemic entities in the dynamic mutual modulation of our particular bodyhood, the *Homo sapiens sapiens* bodyhood, and our particular manner of living, the human manner of living in language. As such, we modern human beings are in bodyhood and behavior the present of a history of coherent changes in bodyhood and behavior in a lineage defined by the conservation of a manner of living in language.

2. We think that the human lineage must have begun some three million years ago in the conservation through the learning of children of a manner of living in language centered on mouth sound productions. And we think that it must have begun at least that early (more than some 200,000 generations ago), considering the changes that a non speaking ancestral hominoid must undergo to attain the present features of the brain, the larynx, and the face, associated in us with spoken language, when starting the path of conservation of a manner of living in consensual coordinations of consensual coordination of behavior through mouth sound productions. As a result of the constitution of the human lineage in the conservation of oral “languaging”, we modern humans have a dynamic bodyhood (brain, larynx, face, breathing pattern, etc) proper to a manner of living in full spoken language. In particular, each of us has a particular “languaging” and speaking brain, that has become so along our particular life history as human beings.

3. As our existence as human beings takes place in our operation in language, the features of our existence that constitute our humanness, pertain to our relational domain and occur in our “languaging”, not in our bodyhood. Thus, notions such as consciousness, reflection in solitude, mind, thinking and intentionality correspond to distinctions that we make of different aspects of our relational dynamics in our operation as human beings, and as such they do not take place in our bodies, nor are they functions localizable in our brains. In other words, consciousness, auto-reflection, mind, thinking, or intentionality do not take place in the body but occur through the operation of the body because they take place or arise as relations or distinctions that we make of relations of the living system with the medium, and involve both, body and medium, in the dynamic flow of living, in the manner that we have described in this essay.

4. Once a brain has become a “languaging” brain, its recursive operation in the domain of linguistic behavior through the process described in III.9, will give rise to new phenomenal dimensions in this domain. Let us start that process with an organism that, like our relatives primates or, presumably, our ancestors, lives in a well established linguistic domain, that is a domain of consensual coordinations of behavior. A first recursion in the linguistic behavioral domain, as it becomes part of the manner of living of such an organism, will constitute language and “languaging”, in terms of consensual coordination of consensual coordinations of behavior (Maturana, 1978). At the same time, as the circular processes of the brain become coupled to the linear flow of “languaging”, that brain becomes a “languaging” brain. Furthermore, the first recursion of coordinations of linguistic behavior, as it constitutes language, constitutes objects, by making a consensual coordination of behavior a token or object, for other consensual coordinations of behavior. From here on, objects, different kinds of objects will arise in language with every new recursion, and the kind of these objects will depend on the behavioral circumstances in which the new recursions occur. Thus, a second recursion gives rise to observing, that is, the distinction

of the operation of distinction of an object. A third recursion gives rise to the observer, in the distinction of observing that localizes observing. Self-consciousness, that is, the observing of the observer, will arise in the fourth recursion of the coordination of coordinations of consensual behavior. The fifth recursion gives rise to the experience of responsibility as self-awareness, and the sixth gives rise to the experience of freedom as self-awareness of self-awareness. All these operations are operations in language, that is, features of the operation of the organism (*i.e.*, human being) in its relational space, and although they require the nervous system to take place, do not take place in it. Or, in other words, recursive linguistic behavior is not an operation of the brain, and is not determined by a particular feature of the nervous system. Furthermore, it follows from what we have said so far, that not all nervous system can participate in the generations of recursive linguistic behavior, and that not all the nervous systems that can participate in the generations of recursive linguistic behavior integrate animals whose manner of living can become a "languaging" manner of living.

5. Once a brain has become a recursive "languaging" brain, it will operate giving rise through its internal dynamics as a closed network, to sensory/effector correlations that pertain to the flow of "languaging" even when the organism that it integrates is alone, or doing nothing apparent to an external observer. This is apparent in daily life when one observes a person, for example, answering a question after a long silent delay, or generating a discourse without previous antecedents in an immediate conversation. Reflections in solitude, meditation in full self-awareness, dreams as meaningful experience in a "languaging" situation, logical operations, intuitions, poetic abstractions, understanding, therefore, become unavoidable possibilities once a brain has become a "languaging" brain, because such a brain belongs to an organism that has had an epigenetic history in co-ontogeny with other "languaging" beings, in a multidimensional relational space.

6. When an observer observes two moments of the flow of the behavior of an ani-

mal, and it seems to him or to her that the second is logically derived from the first through some intervening internal process, while he or she cannot deduce the connection from the relational situation of the animal solely, he or she says that such animal thinks, and calls thinking the internal process that gives rise to the second behavior. A case of this kind is, for example, when we ask a question and the person addressed says "let me think," and after a while gives an answer coherent with our question. Another case is when we see a dog stop in front of what seems to us to be a dilemma, and, when the dog eventually moves again in what appears to us as a choice, we say: "the dog was thinking what to do". What happens in these situations is frequently explained by proposing that in one or another way the nervous system of the person or the animal is operating with a representation of the medium in the generation (thinking) of a behavior adequate to the circumstances in which it found itself. But, the nervous system, as we have shown, does not and cannot do so. What the nervous system does while the animal is "thinking", is to operate in its internal dynamics according to the structure it has at that moment as a result of the structural changes it has undergone contingently to the living of the animal (see especially points II.5 and III.5). According to this, the internal dynamics of that nervous system will give rise to a succession of actions that cannot but be logically or coherently connected between them in the context of the historical circumstances of the realization of the living of the animal. So, the expression "thinking" is a manner that the observer has of indirectly referring to the internal operation of the nervous system as it participates in the generation of behavior. We can say with respect to this, that every animal has a brain that thinks according to the manner of living that it lives. The human brain thinks in language.

7. Intentionality is a commentary that an observer makes about the flow of the behavior of an animal, as he or she relates the present behavior with the outcome that it may have, and does so speaking as if the outcome were an argument in the generation of the behavior that gives rise to it. Intentionality is not a feature of the operation of

the nervous system. But, as intentionality becomes part of the manner of living of the observer, as he or she lives in conversations of intentionality, the structure of the nervous system of the observer changes in a manner contingent to that manner of living, and begins to generate an internal dynamics that gives rise to sensory/effector correlations that entail intentions. The nervous system of the observer becomes an intentional "language" brain, but intentionality, as a relational feature of the flow of behavior, remains a feature of the relational space in which the observer lives.

8. The space of interactions and relations in which we human beings live, with all its dimensions, apparent and non apparent to the observer at any moment, we have called the relational and interactional human psychic space. Non-human animals also live in a relational and interactional psychic space in which the observer can distinguish apparent and non-apparent dimensions. In us, the dimensions that are at any moment non-apparent to us as observers, constitute at that moment of observation the unconscious dimensions of our relational and interactional psychic space. The nervous system, therefore, changes its structure in the course of the encounters of the living system in the medium in a manner contingent to the course of those encounters in all dimensions, regardless of whether these are apparent or not to the observer at any moment. As a consequence, a human brain necessarily follows a course of changes contingent to the conscious and unconscious dimensions of the relational and interactional existence of the human being that it integrates, and has an internal dynamics that gives rise to sensory/effector correlations in the conscious and unconscious dimensions of the human relational and interactional psychic space. Furthermore, since self-awareness, and self-consciousness take place as operations in the relational and interactional domain of the organism, they arise generated through the participation of a brain activity that is necessarily inaccessible to self-awareness or self-consciousness in its own terms. The operation of the nervous system is of a completely different kind with respect to the dimensions in which conscious life takes

place, and then is strictly also unconscious or aconscious.

9. In our culture, we speak of mind to explain phenomena that the observer distinguishes as taking place in the relational space of the organism: intentions, purposes, concerns... Moreover, in our culture we speak as if we were referring to an entity that may have a location in the brain and may interact with other minds or the body. Thus, questions such as "How do the body and the mind interact?" seem meaningful and legitimate. From all that we have said it should be apparent that there is no such a thing as "the mind" in the operation of the nervous system, and that "the mind" is nothing but an explanatory notion. In these circumstances, the questions about mind/body interactions can be reformulated as follows: "How do relational phenomena have consequences in the body dynamics?". This is one of the questions that we have answered in this essay, as we have shown, in general, that the structure of the nervous system changes in a manner contingent to the flow of the changing relations of the actual living of the organism in conservation of living. And, by doing this, we have also shown in particular, that what happens in language (in all the dimensions that arise through the recursion of the linguistic behavior) also becomes, as part of the relational space, part of the domain of transformation of the human nervous system, giving rise to what appears as mind/body mutual modulations. No single thought, desire or reflection is ever trivial or inconsequential in the flow of changes of the human "language" brain.

V. FINAL REFLECTIONS

Language, self-consciousness and mindedness are different forms of existing in the relational domain in which a living being lives, not manners of operation of the nervous system. At the same time, we have shown, the nervous system become transformed along the living of the organism in a way that it generates the proper sensory/effector correlations for the manner of living it lives. To understand the simplicity and richness of this situation it is necessary to

understand: A). That the nervous system is constituted as a closed neuronal network in structural intersection with the organism at the latter's internal and external sensory and effector surfaces, and B). That every organism has, as a result of its phylogenetic history, a dynamic structure congruent with its dynamic medium, so that it can realize its manner of living as a matter of course. It is due to these two basic conditions that the nervous system can undergo structural changes in conservation of the realization of the living of the animal, even though this living is changing continuously. It is also due to these two conditions that each kind of animal has different constraints for its historical structural and behavioral changes, which are proper to their respective manners of living.

The case of the lady gorilla Koko (Patterson, 1978a, b; Patterson and Linden, 1981) is a good example. She, as a gorilla, has a brain that is evolutionarily developed for consensuality as well as for emotional attachment as a child. Due to these two conditions, she is open to the possibility of a coexistence in coordination of consensual behavior, if living in a relational domain that makes that an operational possibility. In these circumstances, when she begins to be brought up in a human "linguaging" relational domain, she becomes transformed accordingly, and now she can operate in language and do all the fundamental operations that we do in language. Her brain has become a "linguaging" gorilla brain, she continues living the basic gorilla emotionality, but at the same time, with a "linguaging" brain, she does things proper to "linguaging". Nothing fundamental has changed in her brain as such, but her manner of living has changed and she can do now things that pertain to the relational space which she could not do before.

What we have said in this article is also valid in general terms for the history of any system in which one can distinguish the structural intersections of two entities that have non-intersecting operational dynamics. When even structural intersections happen, the two operational domains can become

generatively coupled, so that what occurs in one domain can modulate what occurs in the other through the reciprocal generation of structural changes. In the living system, the encounters of the organism at its sensory surfaces modulate the structure of the nervous system, so that this changes the flow of its operations, and through the structural changes that the nervous system triggers at the effector surfaces of the organism, the nervous system modulates the flow of the behavior of the organism. This is the secret of the operations of the nervous system and the organism that makes possible what we call "mental phenomena".

REFERENCES

- CRICK F (1994) *The Astonishing Hypothesis*. New York: Charles Scribners's Sons
- McFARLAND D (1993) *Animal Behaviour*. Essex: Longman Group
- MATURANA H (1969) Neurophysiology of cognition. In: P GARVIN (ed) *Cognition: a Multiple View*. New York: Spartan Books. pp 3-24
- MATURANA H (1970) *Biology of cognition*. BCL Report 9 (Biological Computer Laboratory, Department of Electrical Engineering, University of Illinois)
- MATURANA H (1978) *Biology and language: the epistemology of reality*. In: G MILLER, E LENNENBERG (eds) *Psychology and Biology of Language and Thought*. New York: Academic Press. pp 51-121
- MATURANA H (1990) *Science and daily life: the ontology of scientific explanations*. In: W KROHN, G KUPPERS (eds) *Self-organization: Portrait of a Scientific Revolution*. Dordrecht: Kluwer Academic Publisher. pp 12-35
- MATURANA H, MPODOZIS J (1987) *Percepción: configuración conductual del objeto*. Arch Biol Med Exp 20: 319-324
- MATURANA H, MPODOZIS J (1992) *El origen de las especies por medio de la deriva natural o la diversificación de los linajes a través de la conservación y el cambio de los fenotipos ontogénicos*. Museo Nacional de Historia Natural de Chile, Publicación Ocasional 46
- MATURANA H, VARELA F (1973) *De Máquinas y Seres Vivos*. Santiago: Editorial Universitaria
- MATURANA H, VARELA F (1980) *Autopoiesis and Cognition: The Realization of the Living*. Boston: D Riedel Publishing
- PATTERSON F (1978a) *Conversations with a gorilla*. National Geographic Magazine, October, pp 465-488
- PATTERSON F (1978b) *Linguistic capabilities of a lowland gorilla*. In: FC PENG (ed) *Sign Language and Language Acquisition in Man and Ape: New Dimensions in Comparative Pedolinguistics*. Boulder: Westview Press. pp 161-201
- PATTERSON F, LINDEN E (1981) *The Education of Koko*. New York: Holt, Rinehart & Winston.