CHANGING REALITY:  
A NEUROPHYSIOLOGICAL STANCE  
WITH REGARD TO  
PATTERNS OF CONTEXTUAL RELATIONSHIP

A Thesis

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by

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"What can't be said can't be said, and it can't be whistled either."

--Ram Tirtha
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PRELIMINARY REMARKS

This thesis presents a new relational stance with regard to the neural basis of our perception of contextual relationships. It utilizes information from a variety of sources, including neuropsychology, cybernetics, and linguistics, and employs a rather scientific vocabulary. The rationale for dealing with perceptual phenomena from a neuropsychological standpoint, and for using a technical terminology, is simply that this appears to be a concrete and denotative way of regarding the subject. It is hoped this new approach to the subject will generate insight and stimulate thought about contemporary notions of "art".
STATEMENT OF PURPOSE

The purpose of this thesis is to change the reader. The change to be brought about is the behavioral transformation of the nervous system interactions of the reader, whom "we" as observers view as a living system, or, more specifically, as an organism implicitly capable of nervous system interactions. An understanding of the term "behavioral transformation" will emerge as a result of the process of transformation itself.

Learning is the means by which this transformation will be accomplished. Learning connotes change since it is through observed changes that we describe behavioral transformations. Consequently, learning implies some alteration in those relationships which we take as descriptions of separate entities. "Behavior" demonstrates such an alteration. Certainly interesting questions arise concerning "behaviors" attributable to "inorganic" systems, but since the focus of this thesis is an organism, namely the previously mentioned "reader", it is of more interest to concentrate on the behaviors of organisms. It may be valuable at this point to specify some of the characteristics of learning and to adopt a terminology for describing those characteristics. Humberto Maturana, a distinguished neurophysiologist, has provided a terminology which may be useful in arriving at precise descriptions. According to
Maturana, "Learning as a process consists in the transformation through experience of the behavior of an organism in a manner that is directly, or indirectly, subservient to the maintenance of its basic circularity"¹ and furthermore, says Maturana, "...this transformation is an historical process such that each mode of behavior constitutes the basis over which a new behavior develops, either through changes in the possible states that may arise in it as a result of an interaction, or through changes in the transition rules from state to state."² Next, "an organism cannot determine in advance when to change and when not to change,"³ nor can it make a priori determinations about the functional significance of certain changes. Finally, according to Maturana, an organism has the capacity to modify (change) another organism through "interaction", in which behaviors are interdependent, e.g.: fight and courtship, or through "communication", in which behaviors are parallel, e.g.: linguistics or orientation.⁴

It is within the realm of "communication" that one may

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2. Ibid., p. 55.

3. Ibid.

4. Ibid., p. 41.
utilize the technique known as "educating" to facilitate the process of learning. The English verb 'to educate' is derived from the Latin verb ducere, meaning "to lead," and thus, at least at an etymological level, 'educating' denotes 'leading'. This leading may assume various forms; one may be led out of some state or location into another,—by informing for example, one may be led away from some position toward another,—by persuading for example, or, finally, one may be led on to some level rather than be led off, that is 'misled'. One of the most effective techniques for leading one on is the process of asking "leading questions." It is this process which I shall attempt to utilize, at least to some extent, in changing the reader.

THE NOTION OF "REALITY"

"Reality" involves the recognition of patterns of contextual relationship. Contexts provide us with the possibility of becoming aware of objects. Objects do not exist independent of contexts. Any two organisms which have been apprised of the existence of an object, either through communication, e.g.: an orientation toward an object, or through interaction, e.g.: a direct involvement in a "chain of interlocked behaviors"6 with another organism/object, are aware of the object only because it relates to the context in which it occurs.

Interestingly, the organism also becomes an element in the relationships between the object and its context and, in some instances, provides the context in which an object exists. The organism previously referred to as the 'reader' is such an organism. To some extent, that which enables us to regard 'the reader' as a distinct organism from other organisms is our ability to "objectify" him by placing him in a context. In this case, the context which permits the object (reader) to exist is that context in which he exhibits certain behaviors, such as 'reading', which enable us to infer that he is behaving through his ability to objectify that which he is 'reading', and thus he may be said

to possess a discrete nervous system. And since the nervous system "expands the cognitive domain of the living system [organism] by making possible interactions with 'pure relations'",7 the reader is enabled to enter into communication, that is, "non-physical interactions between organisms such that the interacting organisms orient each other towards interactions within their respective cognitive domains."8 The apparent paradox produced when readers "generate representations of their own interactions by specifying entities with which they interact as if these belonged to an independent domain, while as representations they only map their own interactions,"9 is resolved by readers becoming "observers", or by becoming "self-conscious". As "observers" readers can recursively generate representations of their interactions and by "interacting with several representations simultaneously [they can] generate relations [italics mind] with the representations of which [they] can then interact and repeat this process recursively, thus remaining in a domain of interactions always larger than that of the representations."10 Or, by becoming "self-conscious" readers

8. Ibid., p. 17.
9. Ibid.
10. Ibid.
are involved in self-observation. That is, "by making descriptions of [themselves] (representations), and by interacting with [their] descriptions [they] can describe [themselves] describing [themselves], in an endless recursive process." 11 Thus the integrity of the reader as a living system is maintained through "abstract thinking" (the ability of an organism to interact with its own internal states), "observation", and "self-consciousness", which all contribute to the maintenance of the basic circularity of the living system and, therefore, to our understanding of the functional significance of its organization.

Contexts, which enable organisms to become aware of objects, are rarely dealt with as objects (as for example, I am dealing with them now) and thus it may be interesting to describe them as they are now objectified. A context, as I am using the term, refers to an inclusive relational structure, thus a context contains more relationships than an object which is an included body of relations. Since the possibility of our awareness of the object is secured through our regard to relationship, every object must embody at least one relationship. We simply have no way of ascertaining the existence of a hypothetical entity containing no relationships. One interesting example of the relationship of inclusive relational structure to included bodies

of relations is encountered when one views the notion of "bodies of relations" as an object, the existence of which is dependent upon its context, i.e.: its relational structure, which is, in this case, the larger (more inclusive) notion of "relational structure." While objects do not exist apart from contexts, contexts may exist for which the only included object is the notion of context (relational structure) itself. No context is required for the inclusion of no objects. One final characteristic of contexts which is significant is that any discrimination (observation) of a context presupposes a necessarily larger context in which the preceding context is an object. Accordingly, every awareness of objects or contexts occurs within a more inclusive relational structure.

In contrast, that context which enables us to objectify learning may be exceedingly inclusive. (It cannot, however, be said to be "maximally" inclusive since contexts may be objectified; thus there is always a more inclusive context than the one being viewed as object, a context which includes the preceding context as object.) We may refer to the context in which the learning process is object as the historical context. Learning is change, and it is within the historical context that the possibility of our recognition of that relationship we call change may be said to exist. That possibility exists only in the historical
context because the recognition of change by the organism brings about change in those relationships we refer to as the organism. Change may be recognized only because it is a relationship (object) and the relational structure which makes up its context includes relations between current and prior states. (The notion of "current and prior states" is, however, only a context, securing the possibility of the recognition of its object; namely change.) Organisms which are capable of recognition are observers in relation to that context (as object). This, "the description of learning [change] in terms of past and present behavior lies in the cognitive domain of the observer; the organism always behaves in the present."12

Recognition of change is pattern recognition. "Pattern" is a term we apply to our descriptions of changes in contextual relationships. Since descriptions of changes are included in the historical context (although organisms behave in the present) it may be said that all change is recognized through alteration or transformation in time. At this point there is a temptation to infer that such alterations are "internal" or "external". Thus pattern recognition might be assumed to be those instances in which the focus shifts (for example, an organism moves through space, looking at

12. Maturana, Biology of Cognition, p. 34.
x at time T and y at time T₁ and in this way the pattern [change from x to y] recognized by the organism might be said to be the result of an "internal" shift or alteration. Likewise pattern recognition might be assumed to occur in those instances in which the locus shifts (for example, if x moves, transforming into y between T and T₁ and if, meanwhile, the organism has not moved the pattern recognized might be assumed to be an "external" alteration). This apparent distinction between "focus" and "locus", "internal" and "external", will be seen as a potentially misleading construct as we examine that pattern of change we call "reality".

"Reality" is the observer's recognition of objects in contexts seen as a relationship. Since change is recognized historically, and since both observers and objects are subject to change, it is more useful to apply the term "reality" to this changing relationship (a context) itself rather than attempt to specify as "reality" objects which exist only in the context of observers. The relationship between observers and objects itself constitutes "reality."

This approach to understanding the notion of "reality" has been utilized previously in several contexts. It is not altogether unlike the Eastern concept of reality; namely that "The tangible world [reality] is movement,...not a
collection of moving objects, but movement itself."\textsuperscript{13} This point of view is not, however, exclusively Eastern, nor is it unique. A similar concept of reality is, for example, described by psycho-pharmacologist Roland Fischer in a paper on hallucinations. According to him, "The perceiving-observing-creating interaction between the metastructure (the self) and the unknowable substructure (the non-self)\textsuperscript{14} results in what we call the superstructure,...The actualized appearance of observational relations or 'reality'."\textsuperscript{15} Fischer thus places emphasis on observing as process, as does Maturana, (both for example choose the term "interaction" to describe relations between the organism and his description of relationships [states of activity] in his descriptive domain.) Fischer also recognizes the nature of the context in which the pattern of change we call "reality" is possible as an historical context, as in his description of the superstructure as ""that which is always becoming and


\textsuperscript{14} "Substructure," as used by Fischer, refers to the world of the physicist, i.e., the substructure is "customarily modeled with 'particles', 'particle interaction', and 'ensembles', which 'lie behind' the phenomena, i.e., stand for a non-spatio-temporal potentiality." Roland Fischer, "The Perception-Hallucination Continuum, A Re-Examination," \textit{Diseases of the Nervous System}, Vol. 30, No. 3, March, 1969, p. 161.

never is.' 

(The notion of "becoming" is, of course, a temporal description in the observer's cognitive domain.)

That pattern of change we recognize as "reality" is the pattern of relationship between an organism and his descriptions of recognizable patterns of relations. Certain aspects of these patterns may be described by the organism as "independent external entities", but this description "is, necessarily, a fiction of the purely descriptive domain", and this notion of reality should, in fact, be applied to this very domain of descriptions in which the describing system (organism) interacts with his descriptions, "as if [italics mine] with independent entities." That to which we have become accustomed to describing as sensory experiences of concrete, external entities are actually "states of relative activity between neurons that generate new descriptions." 

We (i.e., reading, observing, recognizing organisms, the possibility of whose existence is 'realized' through the relation, "discrete nervous system" in the inclusive context "nervous systems") recognize the pattern we identify as "reality" by interacting with relations. The context in


18. Ibid.

19. Ibid.
which the interaction takes place is that relational structure which we can refer to as including relationships between the functioning and the topography of the nervous system. (The function of the nervous system is bound to its topography as we shall see later when we describe the nervous system.)

At this point it becomes clear that a thorough understanding of the misleading internal/external distinction will emerge as a result of a comprehensive explanation of the topography (structure) and functioning (relative state of activity) of the nervous system. Although a totally topographic analysis would ultimately reveal "substructural" phenomena, an elucidation of the nature of nervous system functioning should reveal important aspects of the "meta-structure" as well.

Before proceeding to describe the topography and functioning of the nervous system it is important to consider that any listing or categorization is, in effect, at least one step removed from providing a full description of items listed or categorized since there is always a more inclusive context in which the list exists as object, or as the Gestalt psychologist might assert, 'The whole is more than the sum of the parts';\(^20\) or, to put it another way, "Unless [one] explicitly or implicitly provides a theory that embodies the

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relational structure of the system, and conceptually super-
cedes his description of the components, he can never under-
stand it. Accordingly, the full explanation of the
organization of the nervous system (and of the organism)
will not arise from any particular observation or detailed
description and enumeration of its parts, but, like any
explanation, from the synthesis, conceptual or concrete, of
a system that does what the nervous system (or the organism)
does."21 It is just such a synthesis which I have, up to
this time, implicitly attempted, and which I will, from this
time on, explicitly attempt.

NERVOUS SYSTEM TOPOGRAPHY

The topography of the nervous system reflects a general involvement with the embodiment of change. This embodiment is accomplished at various levels in some of the following ways. First, individual neural cells and the matrices in which they occur change, and the aim of such change is equilibrium within the system in general and between receptor and effector surfaces in particular. Second, physical interactions of the organism which are, in themselves, characterized by change at all levels, are embodied in individual neuronal patterns, similarly subject to change, and not in an unalterable morphology. Third, nervous system parts are interrelated to such an extent that change generated in one area is structurally related to change generated in another area. This simultaneous changingness is largely responsible for our inability to localize function except in terms of the possibility of synthesis of some state of activity, as evidenced by our changing notions of the spatial organization of specific faculties or functions, e.g.; memory. Finally, in those instances where function is viewed as 'constant', that is, where it appears to represent similar classes of concomitant states of activity in an historical context, we realize that this 'constancy' is mapped on a continually changing morphology.

The nervous system interacts only with relations. The
neuron is the topographic unit of the nervous system in the sense that it is a cell, and to the extent that cells in living systems may be considered "independent integrated self-referring metabolic and genetic" units. Individual neurons vary in structure because of the nature of their particular genetics and of their own history of interactions. Because of this double—genetic and somatic—variability "no two nervous systems of animals of the same species...are identical." They, in fact, resemble one another "only to the extent that they are organized according to the same general pattern." Because the nervous system interacts with relations it is not surprising that its topography reflects a high degree of interrelationship, such that particular parts are simultaneously related to numerous other parts. For example, the ascending reticular activating system located in the area of the brain stem is crucial, because of its arousal function, to the activity

24. Ibid.
25. It is this overall pattern of interrelationship that has historically resulted in difficulties in describing the spatial organization of nervous system activity. For example, descriptions of the "horizontal" or "vertical" arrangement of certain pathways have presented problems in some areas of neurophysiology. cf. R.W. Sperry, "The Great Cerebral Commissure," Scientific American, January, 1964, (reprint).
of cortical areas. It is also strategic in its location with regard to the convergence of receptor and effector channels. Because of an intricate neural feedback network, activity in the cortex can stimulate neural firing in the reticular system which, in turn, participates in the arousal of the organism, etc., creating a simultaneous, loopic pattern of interrelationship.

That which we might call the boundary of the organism, or that change we can recognize as defining the 'identity' of a given organism is obviously a change in the types of relations with which a particular organism is observed to interact. "At this boundary there are sensors (the sensory surfaces) through which the organism interacts in the domain of relations, and effectors (the effector surfaces) through which the nervous system modifies the posture of the organism in this domain."26 The effectors change the state of activity of the receptor surfaces during the interactions of the organism, thus the nature of nervous system activity resembles the action of a feedback or recursive circuit.

"The architectural organization of the nervous system is subordinated to the order of the sensory and effector surfaces."27 Thus the central nervous system appears, to

27. Ibid., p. 28.
some extent, as a result of conformal mapping of those surfaces. Furthermore, "as a result of its architectural organization every point in the central nervous system constitutes an anatomical localization with respect to... the possibility of synthesizing some specific conduct (state of neural activity)."28 Anatomical localization, however, is only an operational framework, and a particular cell location does not reflect a particular, embodied relationship. "These locations are to be viewed in terms of areas where certain modalities of interactions converge, and not as localizations of faculties or functions."29

For an observer, an organism may appear to engage in physical interactions with independent entities, "yet, what modifies the nervous system of the observed organism are the changes in activity [function] of the nerve cells associated with the sensing elements,"30 and the physical interactions engaged in by the organism are involved only in the sense that they are "embodied" by those changes. Furthermore, original physical interactions may be drastically altered when, embodied as states of relative activity they "become units of internal interactions and generate

29. Ibid., p. 30.
30. Ibid., p. 32.
additional relations, again embodied in states of relative activity which in turn may also become units of internal interactions, and so on, recursively. "31

In describing the topography of the nervous system there is a temptation to assert that anatomical organization is a physiological constant which provides the matrix in which activity is observed to occur. Such a stance neglects the changing character of the organization which secures the possibility of embodying change. By observing the organism within an embryological and ontogenetic context it becomes apparent that "as the minute embryo or fetus or larva grows to adult proportions, the nervous system undergoes enormous alterations in mass, dimensions, inter-neuronal relations, in the numbers of cells and their sizes...[yet] patterns of performance remain relatively stable in spite of these variations of the underlying substrata."32 Thus "the nervous system does not change in its essential functions during growth, although its anatomical substratum is in constant expansion."33 It must be noted, however, that the perception of 'functional continuity' occurs only in the domain of experience of an observer. "Although at any moment every

33. Ibid.
neuron functions deterministically with a definite transfer function, and generates a definite pattern of activity in its effector area, the transfer functions and the patterns of effector activity in many of them may change from one moment to another and the organism still will give origin to what the observer would call 'the same behavior.'  

Consequently, "what appears constant [italics mine] for the observer when he ascertains that the same behavior is re-enacted on a different occasion, is a set of relations that he defines as characterizing it, regardless of any change in the neurophysiological process through which it is attained."  

The topography of the nervous system cannot be viewed as a fixed matrix wherein changes take place. As Weiner has intimated, there is every reason to believe that "storage" in the nervous system takes place through alterations of "certain storage elements." Or, stated another way, "Mechanisms for perceiving and responding to stimuli are at least partly generated by earlier stimulation."  

34. Maturana, Biology of Cognition, p. 25.  
35. Ibid., p. 57.  
Furthermore, not only is the overall morphology (topography) of the nervous system characterized by change, but the nature of axonal conduction and synaptic transmission at the level of the individual neuron seems also to be typified by continuous change. (Changes for example in the permeability of neural membranes to concentrations of sodium and potassium ions, or changes in relative amounts of transmitter substances released at synaptic junctions.)

Clearly, the topography of the nervous system reflects the changing relational nature of nervous system interaction. From the level of the individual self-referring cell, the neuron, to the level of overall structural areas, it is characterized by interrelationship. Moreover, because of the general reflexive quality of its interrelationships, the maintenance of equilibrium between areas and observed functional continuity through ontogenetic structural change emerge as significant elaborations of the basic circular pattern of organization of living systems. It is upon this organizational basis that the nervous system functions.
NERVOUS SYSTEM FUNCTIONING

If the embodiment of change is the basis of the topography of the nervous system, 'changing' itself must be considered the basis of nervous system functioning. Because nervous system activity is subordinate to its topographic basis which, by changing, embodies change, it is apparent that there is no fixed location to which we can attribute the origination or embodiment of functioning. Indeed, as previously mentioned, "same behaviors" can only be construed as groups of relations which satisfy the requirements of descriptive categories generated by observers while, structurally and functionally, engaging in the "same behavior" is strictly impossible for a changing organism engaged, in fact, in changing. (Changing as functioning is, as previously suggested, exhibited to observers through "behavior", that is, changing patterns of relationship at the effector surfaces.) Due to our inability to specify centers of functioning it becomes necessary to consider "conduct itself", (i.e.; relative states of ongoing activity) as the basic unit of nervous system functioning. Certain significant aspects of nervous system functioning may

38. The word 'functioning' is used here in place of 'function' in an attempt to refer to the ongoing nature of those processes under consideration.

be recognized in processes occurring at all levels of observable organization.

At the cellular level, for example, it is clear that individual neurons are engaged in changing states of conduction. "Nerve cells respond at any moment with definite transfer functions [from dendrites and cell bodies as collector areas to axon terminals as effector areas] to classes of afferent spatio-temporal configurations... [within the domain of relations in which the organism is interacting]...generating definite states of effector activity, and not to particular afferent states."40 An emphasis on the configurational aspects of afferent relations is of course, explicit in the Gestalt view of perception. It is not surprising, therefore, to discover a clear example of this aspect of nervous system functioning in areas involved in visual perception, i.e.; in the cells of receptors such as the retina. As a result of their analysis of retinal functioning in the frog's eye, Lettvin, Maturana, McCulloch, and Pitts41 concluded that "The nervous apparatus in the eye is itself devoted to detecting certain patterns of light and their changes, corresponding to


particular relations in the visible world,"\textsuperscript{42} and therefore, that the eye is not mainly concerned with sensing "light, whose local distribution is transmitted to the brain in a kind of copy by a mosaic of impulses."\textsuperscript{43} The eye is not, in other words, involved in receiving a "picture of the world."

Looking at nervous system functioning at the level of groups of neurons, we notice a characteristic sharing of functional activity achieved through an integration of patterns of activity in neural complexes. Evidence for shared functional roles is provided by lesioning experiments which reveal that "Limited lesions or interruptions of transcortical connections produce few or no symptoms. [Consequently,] Behavior seems not to depend on any localized conducting pathways within the cortex. Habits are not stored in any limited area. Such facts point to the conclusion that there is multiple representation of every function."\textsuperscript{44} Because we observe complex patterns of shared functional activity we can infer that "groups of neuronal complexes of different kinds are acting as units, the

\begin{itemize}
\item \textsuperscript{42} McCulloch, Embodiments of Mind, p. 237.
\item \textsuperscript{43} Ibid.
\item \textsuperscript{44} Karl Lashley, quoted in McCulloch, \textit{Embodiments of Mind}, p. 101.
\end{itemize}
properties of which determine the configuration"45 of observed behaviors. Such inferences about the functioning of the nervous system lead us to the obvious assumption that 'the whole (in terms of functioning) is more than the sum of the parts.' Or, stated another way, "The field character of the activities in neuron pools may force us to extend our current concept of the nervous system...We may find that the field properties cannot be adequately accounted for by considering only the neuronal elements."46

Because the nervous system organization alters through experience (e.g.; learning) it can be said to determine which interactions will be accessible at the present moment to the functioning organism. In this sense the "organization of the living system defines a 'point of view', a bias or posture from which...interactions take place."47 But, although the living system's "posture" defines which of the possible "relations holding between its component neurons will modify it at any given interaction,"48 these possibilities do not constitute a representation of physical characteristics of interactions. Consequently, the functional (and

45. Lashley, in McCulloch, Embodiments of Mind, p. 104.
46. P. Weiss, quoted in McCulloch, Embodiments of Mind, p. 120.
47. Maturana, Biology of Cognition, p. 29.
48. Ibid., p. 30, cf. also Sperry, op. cit.
topographic) organization of the nervous system secures the possible "synthesis of behavior, not a representation of the world."49

Another significant aspect of nervous system functioning is the subordination of the system to its own states. The development in certain organisms of the ability to interact with their own internal states of nervous system activity, as if these states were independent entities, had led to an increased "dependency of the organism on its own states of nervous activity."50 In terms of evolution, this reliance "requires an anatomical and functional internal reflection so that the internal organization of the nervous system can project itself onto itself."51 This evolutionary sequence has been reflected in the emergence of predominant mammals, especially primates, notable particularly because they possess tremendous amounts of frontal cortical tissue; the "neocortex...which arises as a center of internal anatomical projection."52

One final relevant characteristic of nervous system functioning is the 'real time' nature of its ongoing activity. 'Real time' functioning implies that interactions of the

50. Ibid., p. 38.
51. Ibid., p. 37.
52. Ibid.
organism involving relationships between receptor and
effector surfaces (observable behaviors, for example) occur
almost instantaneously. Because of the operation of natural
selection in evolution, nervous systems which structure
delays in feedback from the environment ("external" sensory
configurations, or "internal" proprioceptive patterns)
have been selected against. 53 Moreover, those behaviors we
often attribute to "perceptual deficiencies" or conditions
like "epilepsy" may, to some extent, involve some form of
delayed feedback disrupting expected behavior patterns.
Furthermore, some of our common difficulties in 'explaining'
certain behaviors may be the result of our frequent inability
to detect temporal patterns involving long delays, and our
insistence on confusing 'instantaneousness' in our (the
observer's) cognitive domain with the 'real time' of the

53 Certain large reptiles which evolved beginning in the
late Paleozoic period and which became dominant during
the Mesozoic era, displayed interesting adaptations to
the delayed feedback problem. Long-necked herbivores
like Brontosaurus, for example, would have become ex-
tinct even sooner than they did were it not for the
structure of their nervous systems. Such organisms
would have experienced tremendous delays between activ-
ity patterns at receptor surfaces and central processing
areas located in the brain simply because of the dis-
tance over which a nerve impulse would necessarily
travel. Thus feedback about say, the relative position
of rear limbs (as they dangle over a precipice for
example), would not reach interneurons in a reflex arc
soon enough to be beneficial to the organism (by pre-
venting his fall for example). The adaptation which
appears to have taken place in Brontosaurus, which con-
tributed to his longevity, is decentralization of func-
tioning in the form of a ganglionic plexus near the tail.
organism's interactions. Although observers describe behaviors of organisms within the historical context, "the nervous system [of the organism] always functions in the present."\textsuperscript{54} The 'real time' or "present" of an organism's behavior "is the time interval necessary for an interaction to take place."\textsuperscript{55}

To recapitulate then, the fundamental characteristics of nervous system functioning include: 1) the overall interrelatedness of functional integrity of the changing system; 2) the configurational aspect of afferent activity; 3) the sharing of functional responsibility between groups of neurons resulting in 'fields' of nervous system activity; 4) the posturing effect of experience on continued functioning; 5) the subordination of the system to its own states of relative activity, and finally; 6) the 'real time' activity of the system. This functioning occurs in the context of a changing topography, characterized by its overall pattern of individual, organism--specific, structural interrelationship. Although functioning occurs "in" the context of topographic relations, it is not "in" the nervous system structure that functioning is observed, but rather, "through" it. Clearly, any observation about topography involves a consideration of functioning and vice-versa, but


\textsuperscript{55} Ibid.
it must be remembered that functioning is subordinate to
topography in the final analysis.

Before returning to the question of the apparent dis-
tinction between "internal" and "external" phenomena, and
thus commonplace notions of reality, let us examine the
nervous system further. It is through such an examination
that we may gain insight into the exact nature of the
"internal/external" distinction, and into certain aspects
of a neurophysiological basis of our recognition of "reality".
Having discussed the characteristics of the nervous system,
let us now examine certain ways in which those character-
istics have been incorporated into models of the system.
This examination will, ultimately, further our understanding
of "internal", "external", and "reality".
MODELS OF THE NERVOUS SYSTEM

It is not surprising to discover that those models of the nervous system which are most descriptive are those which most closely re-present its actual characteristics. Consequently, those models which are involved with embodying change are most likely to clearly describe nervous system topography and, likewise, those which are involved with changing as an operational process are most likely to clearly describe nervous system functioning. Any model which accurately and completely represented both topography and functioning would no longer be engaged in only description, but would begin to synthesize nervous system operations and would, thereby, begin to provide a "full explanation" of the organization of the nervous system in the sense previously mentioned (page 12). Obviously, difficulties would arise in distinguishing these synthetic representations from that.

56. Misunderstandings often result from mistaking a description for that which is described. For example, certain metaphors (as descriptive devices), because of frequent and imprecise usage, become synonymous with that to which they refer. A further difficulty is that such devices may eventually become totally autonomous from their referents. In the sense that language itself is a metaphor for nervous system activity, (cf. William R. Krueger, Work in process. [unpublished MSS.], also, Paul A. Kolers and Murray Eden, (eds.), Recognizing Patterns, Cambridge, Mass., The M.I.T. Press, 1968,) it becomes crucial that one not mistake statements about (descriptions of) metaphorical models (descriptions) of the nervous system for the actual nervous system.
which they re-present, but those models which we will consider are sufficiently remote from that which they model so that no confusion of this type should ensue.

Among models of the nervous system which appear to re-present certain significant characteristics of the system's topography and functioning is the model of the nervous system as a probability computer. According to this description, the nervous system is a "discrete state machine."57

The basis of this model is the neuron, which operates according to the familiar all-or-none principle (although other factors such as temporal and spatial summation, relative refractory period, etc. influence its operation). Viewing the neuron, then, within a discrete state context, we see that, as McCulloch has asserted, "the a priori, or logical probability that a neuron is in a particular state at a particular time is one-half; that two are in a given state, one-fourth; and so on. Hence information is exactly the

57. It must be remembered, of course, that the notion of "discrete state machines" is a hypothetical construct. "Strictly speaking there are no such machines. Everything really moves continuously. But there are many kinds of machines which can profitably be thought of as being discrete state machines." (Alan M. Turing, "Computing Machinery and Intelligence," in Alan R. Anderson, (ed.), Minds and Machines, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1964, p. 11.) Furthermore, in terms of its overall organization, "the nervous system is certainly not a discrete state machine," (Above, p. 22.) but at the level of the individual neuron it certainly is.
logarithm to the base 2 of the reciprocal of the probability of the state." 58 Furthermore, according to McCulloch, 59 because information can be described in the context of the second law of thermodynamics (entropy must always increase), "this ensures that no machine can operate on the future but must derive its information from the past. It can never do anything with this information except corrupt it." 60 Consequently, the operation of the nervous system, according to this model, obeys the law "that there can be no more information in the output than there is in the input." 61 McCulloch calculates this overall corruption (reduction of information) between the receptor and effector surfaces to be on the order of a hundred million to one. Thus the probability computer model of the nervous system can be seen to replicate certain significant characteristics of its topography and functioning. It describes the posturing of an organism through past experience and its relationship to configurations 62 of afferent activity which are then processed according to assessments of probability at the all-or-none

60. McCulloch, Embodiments of Mind, p. 146.
61. Ibid.
neuronal level of organization. Consequently effector changes are modulated by receptor 'predictions' about the occurrence of any event. In a receptor such as the eye the chance that what it relays "is due to chance is fantastically small, $2^{-100}$, a billionth of a billionth of a billionth of a tenth of one percent." 63

One interesting elaboration on the probability computer model is the notion of alpha rhythm scanning described by W. Gray Walter. For Walter, such a system permits a parsimonious transformation of spatial information into temporal patterns. This system helps account for correspondences between afferent configurations and observable changes in electrical potentials in the brain. 64 The scanning sweep of the alpha rhythm, suggests Walter, "is sort of a logarithmic spiral, more closely coiled at the centre and wider at the periphery of the visual projection regions." 65 This type of description seems not to contradict evidence about the topography of receptor and effector surfaces, e.g., the high degree of visual acuity near the fovea of the eye, where

63. Cf. McCulloch, Embodiments of Mind, p. 76.

64. Relationships between certain configurations and electrical activity have been observed in phenomena like photic driving of the alpha rhythm.

highly discriminating cone cells are abundant, (receptor surface), and the relatively large amount of motor projection area in the cortex devoted to controlling eye movement (effector surface), and thereby positioning of receptor surfaces in relation to inputs. Repetition in time of transformed spatial patterns, provides, for Walter, the basis of prediction of the "probability that...two events are significantly related." 66 This account of the activity of the nervous system extends the view implicit in the probability computer model, that afferent activity is encoded in configurations, a view which, of course, coincides with previous statements about the functioning of the nervous system.

Another significant model of neural activity is one we can describe as the holophonic model of the nervous system. This model is itself an elaboration of a previous description of nervous system activity, namely the holographic model. The holophone can be thought of as the temporal analogue of the spatial--optical or acoustical--hologram. The hologram utilizes coherent laser light or pure tones of sound directed at an object. Reflections of the directed light or disturbances of sound waves produce patterns of interference recorded on a photographic plate as they

interact with a portion of the undisturbed laser radiation, (reference beam), or an undisturbed acoustical wave (reference wave). Once recorded, coded interference patterns (optical or acoustical) can be unscrambled with another laser beam,67 and thus transformed into an observable image. Since the hologram retains not only intensity information, but also phase information, the image that is observed is three-dimensional. That which is stored in the hologram are recorded features which "are themselves non-local, that is to say, each of them defines some internal relationship between the parts of the object. Only when some 'absolute' information [i.e., the reference beam or wave] is made available can the 'relative' information embodied in the hologram be used to re-create the original object."68 The holophone utilizes the principle of non-local information storage but realizes it in the temporal rather than the spatial dimension. "What the holophone essentially records... are correlations between the amplitude of... signals at one time and the amplitude at a later time... It does this by


storing separately each rhythm in the signal." 69 The physical realization of the holophone involves the construction of a black box with one input channel, a series of filters and amplifiers and one output channel. The filters are "a bank of narrow-pass filters, each of which can be regarded as an oscillator with a certain resonant frequency and damping constant." 70 "The output of each oscillator is fed into an amplifier of variable gain, and the memory of the system resides in the gains of all the amplifiers. In recording a signal one keeps a tally of the amount of work done by the signal on each oscillator, and then turns up the gain of its amplifier by a proportional amount." 71 Because the holophone stores information non-locally it appears to coincide with important aspects of nervous system topography and functioning. In the same way in which ablation of one area of the nervous system does not necessarily disrupt the overall functioning integrity of the system, damage to information about the recorded signal as stored in the gains of the various amplifiers in the holophone "will affect only the general quality of the playback, [and will]


70. Ibid., p. 42.

71. Ibid.
not result in the total loss of particular sections." 72 The holophonic model also describes ways in which encoded patterns of afferent activity are unscrambled, that is, resynthesized in response to an appropriate cue. "On receipt of the cue the holophone will immediately emit the rest of the recorded signal, in real time and virtually free of noise." 73 Therefore, the holophonic model replicates the real time functioning of the nervous system and describes a method of "storage" of information through change in storage elements.

One final interesting description of the nervous system is the non-linear system model. This description is in many respects a macro-model, incorporating familiar principles utilized in other models into a general conceptual framework. Stated differently, this model provides a more inclusive context in which to observe nervous system relations. Non-linearity, according to this model, is simply the absence of direct proportionality. A linear expression in mathematics is one which takes the form $F(a + b) = F(a) + F(b)$, where $F$ is a measure function. Conversely, a non-linear expression is one which takes the form $F(a + b) > F(a) + F(b)$, and thus, "A measure of the sum of the parts is larger than the sum of

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73. Ibid., p. 45.
the measure of the parts."74 In extending this notion to mechanisms we see that "if the frequency of an oscillator can be changed by impulses of a different frequency, the mechanism must be non-linear. A linear mechanism acting on an oscillation of a given frequency can produce only oscillation of the same frequency, generally with some change of phase and amplitude. This is not true for non-linear mechanisms, which may produce oscillations of frequencies which are the sum and differences of different orders, of the frequency of the oscillator and the frequency of the imposed disturbance."75

The nervous system of the human organism provides an excellent example of non-linearity. If the spontaneous 8-12 c.p.s. alpha rhythm is regarded as a given oscillation frequency which can be changed by oscillation of a different frequency we are provided with evidence (in the form of an evoked potential) of non-linear operation. Just such an alteration in frequency is produced in the presence of low-frequency photic stimulation. This phenomenon, known as "photic driving" of the alpha rhythm, results in an "attraction"76 of the alpha toward the frequency of the imposed

75. Wiener, Cybernetics, p. 199.
76. Ibid.
disturbance. It also seems reasonable to consider the previously discussed corruption of information between receptor and effector surfaces as indications that nervous system operations on data are non-linear in nature. The non-linear system model of the nervous system clearly describes certain features of its functioning and topography. For example, the non-linear character of nervous system operation relates directly to the way in which functioning and topography determine the accessibility of interactions. Furthermore, the non-linear approach appears to describe the configurational aspect of afferent states, and the further notion that the nervous system interacts with relations rather than with copied representations of stimuli in the world.
CONCLUSIONS

The three models with which we have dealt—the probability computer model, the holophonic model, and the non-linear system model—exemplify various characteristics of actual nervous system structure and operation. The probability computer model points to efferent "posturing" of the organism and to configurational aspects of afferent states. The holophonic model provides an illustration of overall functional integrity (non-localization) and demonstrates the real-time nature of functioning. The non-linear system model furnishes suggestions about interactions with relations rather than with representations, and characterizes a possible disparity between 'input' and 'output'. All three models, therefore, contribute to a generalized description of nervous system topography and functioning. Let us now attempt to synthesize a method of developing these descriptions of the nervous system into a stance with regard to "reality".

Our ordinary notions about the perception of "reality" are based on the premise that "external" entities are retained "internally". The belief that "brain patterns resemble in form, and in a sense copy in miniature, outside objects" 77

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is "the oldest, simplest, and still the most common notion on this matter." This notion, which can be called psycho-neural isomorphism pervades our language and consequently, is difficult to describe. Probably the best approach, then, in dealing with the subject will be to describe more extensively those difficulties inherent in distinguishing between "internal" and "external" in terms of the nervous system. In elaborating on this subject it may be valuable to utilize those characteristics of the nervous system to which the models discussed referred.

"Posturing" of the organism is a characteristic of efferent activity as described by the probability computer model. Because the motor (efferent) activity of the nervous system determines, to some extent, which interactions will be accessible to the receptor (afferent) surfaces of the organism, it is clear that the organism does not statically and automatically 'photograph' discrete objects.

A source of evidence for this motor interaction with sensory surfaces is the disproportionately large topographic area of the cortex which seems to be involved with control of eye movement. Furthermore, in terms of observable

79. Ibid.
functioning, it is clear that a continual repositioning and re-orienting by means of motor activity (saccadic eye movements, for example) helps determine receptor interactions. Even further evidence for efferent control of afferent surfaces is provided by experiments in which "electrical stimulation of efferent tracts...resulted in changes in the amount of neural activity recorded from afferent fibers originating in receptors" 82 (a reversal of ordinary sequences). Also, studies of the so-called "association cortex" reveal its ability to alter "redundancy", i.e., the "number of fibers used to carry a signal" 83 in input channels. Moreover, "instead of ever more complex integrations being effected in brain regions remote from input channels,...these remote regions exert their influence downstream at various stations--controlling, programming, and organizing the events directly in the input channels...The effect obtained is similar to that produced in a computer program by the addition of recursive servo-like, hierarchically arranged loops established as subroutines." 84 It seems reasonable to assume, based on a consideration of some of these facts, that nervous system


83. Ibid., p. 465.

84. Ibid., p. 464.
"input" is to a large extent determined by "output" patterns. Moreover, "output" patterns develop quite independent of any "input" modulation. "It is a fact that most of the basic motor patterns of behavior are developed within the nervous system by virtue of the laws of its own embryonic differentiation without the aid of, and prior to the appearance of, a sensory input from the outside world. The basic configuration of the motor patterns, therefore, cannot possibly be a direct product of the patterns of the sensory input." 85

The complex interdependence of afferent and efferent activity, the high degree of control of input exerted by efferent pathways, and the relatively observable nature of many patterns of motor activity has led to the suggestion that perception itself is best regarded in terms of motor configurations. Sperry, for example, views perception as patterning of adaptive actions, or simply "an implicit preparation to respond." 86 "Posturing", then, becomes crucial to this approach as is "evident in the general tendency to perceive selectively what one is already looking for and expects to see." 87 From an observational standpoint, "The presence or absence of adaptive reaction ["posturing"]

85. Weiss, quoted in McCulloch, Embodiments of Mind, p. 103.
87. Ibid.
potentialities,...ready to discharge into motor patterns, makes the difference between perceiving and not perceiving."\(^{88}\)

Still another approach to the question of perception is Fischer's suggestion\(^{89}\) that perception and hallucination form a continuüm, and that locations of various behaviors on this continuüm can be determined by assessments of the ratio of motor to sensory activity. Presumably, a one to one relationship is only one of a number of possible ratios. For Fischer, a disproportionate relationship between motor and sensory states implies relocation on the continuüm. "Voluntary\(^{90}\) motor performance,"\(^{91}\) observable in nature, is utilized to "verify" or "measure" the flow of information in the human.

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organism's "self-referential" domain of interactions. With regard to the perception-hallucination continuüm, then, hallucinations emerge as instances of restricted motor verification, or "intensely active sensations with blocked peripheral voluntary motor manifestations." Not only does Fischer's schema provide the basis for a redefinition of perception as a relationship pattern, but it also relates to the notion that efferent activity influences afferent configurations. Since, for Fischer, the "proof of the sensory pudding is in the motor eating," we can infer that decrease in the motor to sensory ratio results in altered patterning at the receptor surfaces (as in accommodation which will be discussed later), and hence, 'hallucination', (or 'dreaming', eidetic imagery, etc.).

Patterning into configurations is a characteristic of the organism's afferent activity as described, again, by the probability computer model of nervous system operation. The afferent activity of an organism is not simply a physical replication of all energy in any way impinging on the receptor


93. Ibid.

94. Ibid., p. 161.
surfaces. Rather, it involves a structured, selective\textsuperscript{95} arrangement into configurations, independent of consideration of the source of stimulation. Therefore, afferent activity may describe 'simulated' (other than ordinary physical and "external") entities or perceptions. Consequently, patterns of afferent activity for which there can be no "motor verification," are as accessible to the organism as those that can be verified. Evidence for afferent patterning is provided by some research in neurophysiology.

Afferent patterning appears to occur at many levels along the afferent pathways. As Lettvin, Maturana, McCulloch, and Pitts determined in their classic study of the frog's visual system,\textsuperscript{96} "the eye [as an afferent surface] speaks to the brain in a language already highly organized and interpreted, instead of transmitting some more or less accurate copy of the distribution of light on the receptors."\textsuperscript{97} Furthermore, using the visual system as a model for afferent activity, it becomes clear that in vertebrates "the retina is more than just the biological equivalent of a photographic emulsion. The transformation of the visual image into nerve

\textsuperscript{95} Afferent patterning is not necessarily 'selective' in the sense of 'consciously chosen,' but definitely is 'selective' in the sense of 'species specific,' or 'phylogenetically selected,' in terms of evolution.

\textsuperscript{96} Cf. McCulloch, \textit{Embodiments of Mind}, pp. 230-255

\textsuperscript{97} Ibid., p. 251.
impulses traveling along the optic nerve calls for a considerable amount of processing."\(^{98}\) Depending upon the complexity of the visual system of the organism under consideration, selective processing-patterning of visual information is observed to occur at the level of the retinal ganglion cells, the optic tectum, and even the superior colliculus, as well as in the visual cortex (in the primates for example).\(^{99}\) Obviously afferent states represent a restructuring and re-configuring of physical interactions to which they relate. Beyond this, afferent states may be presentations of configurations for other than ordinary, or even 'non-existent' "external" relations.

Configurations which represent transformations of "non-external" physical data occur in a variety of situations. Many of these patternings are described by observers as hallucinatory phenomena, or 'misperceptions', although they are, for the experiencing organism, relatively contiguous with other occurrences of configuring. An example of this type of configuring is what we commonly refer to as retinal phosphenes. Phosphenes may arise spontaneously, or in response to chemical or mechanical stimulation of the receptor


\(^{99}\) Ibid.
surface. Varying in shape, intensity and hue, they represent elaborate afferent patterns resulting from extra-external sources. Like phosphenes, rich sensory experiences in various modalities can also be induced by direct electrical stimulation of the brain's surface. One other instance of afferent patterning in the absence of physical entities is the phantom limb phenomenon. Here patterns, apparently originating higher along sensory (tactile and kinesthetic) pathways, produce intense experiences for the organism of afferent activity in the absence of actual receptors.

Evidence for patterning in afferents is also derived from situations in which, through reduction in "external" environmental pattern, organisms experience disruptions in the flow of afferent information. In the Ganzfeld phenomenon, for example, diffuse white light encompassing the entire visual field produces a disturbance described by human subjects (acting in an observational context) as the disappearance of the ability to see. Similarly, in

101. Ibid., p. 84.
deprivation situations such as the one structured by Lilly,\textsuperscript{103} subjects report loss of important pattern cues from their immediate environment. Immersed in water at 98.6°F, these subjects describe a loss of ability to describe the limits of their 'body image'. Thus it is clear that patterning is an important concommitant of the ordinary functioning of the organism in an environment. Interruptions of the ordinary flow of patterned afferent activity, based to some extent on physical interactions, may result in what the observer, at least, regards as disturbed perceptions.

The \textit{holophonic model} of the nervous system describes the system's overall functional integrity and refers to its real-time operation. The holophone, in its non-local storage of information, emphasizes the previously mentioned multiple functional representation that enables the nervous system to remain operationally intact, even when relatively large areas of it are ablated or perturbed.\textsuperscript{104}

'Real-time', in this context, is probably best described as the interval of the organism's interaction. For the observer, however, an interaction is accessible only through observed changes in receptor-effector surface relations.


\textsuperscript{104} Cf. Sperry, "The Great Cerebral Comissure.: pp. 1-4.
Thus the 'time' period of an interaction as seen by an observer is quite distinct from the 'real-time' of an interaction within the organism's cognitive domain. Stated another way, "time is an experimenter's variable, not a subject's variable. The fact that different perceptual processes vary with time merely indicates that they take different amounts of time to run off, not that time itself is experienced as part of the input. In fact the judged duration of an event is often related to the complexity of its processing, and not to its temporal duration."105 The 'real-time' of the organism's experience is of such a nature that an interaction may terminate before observed effector relations have terminated, or conversely, it may persist long after effector relations have been observed to continue. One clear example of termination is accommodation. "Like all senses, the retina is subject to accommodation; that is, the constant maintenance [the observed aspect] of a stimulus reduces its ability to receive and to transmit that stimulus."106 Thus the 'real-time' of the organism's interaction in this situation is the period during which the stimulus is operated on, while for the observer the operation appears to continue past its termination. In the phenomenon known as after-image the opposite is the case. Here an organism

105. Kolers, Recognizing Patterns, p. 35n.
continues to interact (with enhanced sensitivity in some instances) with a stimulus which has ceased to impinge on receptor surfaces. Furthermore, so-called "attention: effects may enter the 'real-time' interactions of the organism. Observations of this effect have shown "that the configurations of the electrical responses in the input channels evoked by light or sound stimulation were different when an animal attended to the stimulation and when it was distracted." Attention" then, can alter the 'real-time' interactions of the organism without providing observable effector relations to demonstrate the "attending". Because of the nature of nervous system functioning, particularly the nature of axonal operations (i.e.: the "all-or-none law, threshold, strength-latency relation, and refractory period") activities within the domain of experience of the organism are not adequately described within the observer's temporal context.

The non-linear system model of nervous system functioning describes several important characteristics of nervous


system operation. It suggests that the nervous system interacts with relations between its own states rather than with representations of "externals", and furthermore, that input to the system does not stand in direct proportion to output. Since these notions are important in fully understanding the nature of nervous system activity, and since they provide a further basis for comprehending the difficulties inherent in distinguishing between "internal" and "external" states, let us examine them further. Fortunately, Maturana has provided an insightful analysis of these specific matters.

According to Maturana, the nervous system interacts only with relations. If an "external" interaction occurs, "the state of activity of the nervous system is modified by the change in relative activity of the neurons, which... embody the relations given in the interaction. Accordingly, that which the different states of activity thus generated can be said to represent are the relations given at the sensory surfaces by the interaction of the organism, and not an independent environment [italics mine], or, least of all, its description, in terms of entities, that lies exclusively in the cognitive domain of the observer."\(^{110}\)

Similarly, when an "internal" interaction takes place, the new state of relative activity of the neurons represents the

relations given in the interaction, and "not an independent set of relations or their description, in terms of some kind of entities [italics mine], such as thoughts, that lie only within the cognitive domain of the observer."111

Maturana cites Held and Hein's well-known experiment112 as a paradigm of nervous system interaction with relations rather than with representations. In this experiment, two cats are placed in an apparatus permitting one to visually experience an environment as he moves through it, while the other experiences the same environment only visually. Those cats subjected to restricted motor feedback show impaired ability to perform visual tasks on later testing occasions. Thus it is apparent that "'visual handling' of an environment is no handling of an environment, but the establishment of a set of correlations between effector (muscular) and receptor (proprioceptor and visual) surfaces, such that a particular state in the receptor surfaces may cause a particular state in the effector surfaces that brings forth a new state in the receptor surfaces...and so on."113 Consequently, interactions with representations (e.g. visual

111. Maturana, Biology of Cognition, p. 34.


'images') are not adequate for establishing the behavior of an organism in an environment (which, of course, is the basis of all our observational stances). Behavior is viewed metaphorically by Maturana as an "instrumental flight," through an environment which is not 'represented' to the organism but only 'presented' (since, in the organism's experience, every encounter is the first encounter) through relations between states.

An understanding of the character of nervous system interactions as relations rather than representations also provides the basis for a new stance in regard to certain important behavioral transformations (e.g., learning and memory). The synthesis of behavior (alterations of observed relations between effector and receptor surfaces) emerges as a significant aspect of both learning and memory.

"Learning is not a process of accumulation of representations of the environment, it is a continuous process of transformation of behavior through continuous change in the capacity of the nervous system to synthesize it. Recall does not depend on the indefinite retention of a structural invariant that represents an entity (an idea, image, or symbol), but on the functional ability of the system to create, when

115. Cf. John Brockman, By The Late John Brockman.
certain recurrent conditions are given, a behavior that satisfies the recurrent demands, or that the observer would class as a re-enacting of a previous one. 116

As the non-linear system model clearly illustrates, that which an observer considers as input to the nervous system undergoes tremendous modification as a result of the process of interaction. Consequently, unless an observer can specify a focus of observation, it is difficult to determine which inputs are transformed into which outputs (or, for that matter, which inputs are lost as a result of corruption in this non-linear system). Furthermore, according to Maturana, the observer's locus is important as well. "To the observer,...the nervous system, as a mode of organization, seems to begin at any arbitrary point [focus] that he may choose to consider; the answer to the question what is the input to the nervous system? depends entirely on the chosen point [locus] of observation." 117 Because of the state-determined nature of nervous system functioning, Maturana suggests that "unless they imply their origin (through concomitant events, their locations, or, through the consequences of the new interactions which they originate) there is no possible distinction between internally and

117. Ibid., p. 31.
externally generated states of nervous activity." However, this distinction, untenable as it is, is drawn by certain organisms, namely, those organisms which engage in "abstract thinking." An organism possessing "a nervous system that is capable of treating its internally generated states of activity as different from its externally generated states, that is, of distinguishing their origin, is capable of abstract thinking." The capability of engaging in abstract thinking, that is, interacting with one's own states, enlarges the cognitive domain of the organism by permitting recursive interactions in increasingly larger contexts. (The cognitive domain of an organism may be enlarged without disrupting the living system's circular organization, [i.e.; that by which it retains its identity in an ecological context] because one form of enlargement is simply the specification of new means of achieving circularity.) A further dimension of the cognitive domain includes interactions with representations of interactions, namely linguistics. Accordingly, it is within the sub-domain of linguistics that an organism interacts with representations of interactions with its own states, (these latter interactions have been described as "abstract thinking").

118. Maturana, Biology of Cognition, p. 32.
119. Ibid., p. 36.
Linguistic interactions provide a context in which objects may be recognized. As previously asserted, it is through "interaction" or "orientation" that an organism is apprised of an object in his domain of experience. In "interaction" two organisms are interlocked in sequences of behavior in which the "ensuing behavior of each of them depends strictly on the following behavior of the other."\textsuperscript{120} In "orientation," on the other hand, one organism generates a description of some aspect of the classes of interactions into which that organism can enter, which orients a second organism within its own cognitive domain to an interaction therein. "This can take place only if the domains of interactions are widely coincident;\textsuperscript{121} in this case no interlocked chain of behavior is elicited because the subsequent conduct of the two organisms depends on the outcome of independent, although parallel, interactions."\textsuperscript{122} One pivotal difficulty that arises in pursuing further a discussion

\textsuperscript{120.} Maturana, \textit{Biology of Cognition}, p. 40.

\textsuperscript{121.} This need for coincident domains provides the basis for the necessary creation of consensual contexts in establishing communication with non-human organisms. Such organisms are by no means excluded from engaging in the types of interactions we have discussed, but coincident domains are needed to secure a common basis for orienting behaviors where such organisms are involved. Cf. R.A. Gardner and B.T. Gardner, "Teaching Sign Language to a Chimpanzee." \textit{Science}, Vol. 165, 1969, pp. 664-672.

\textsuperscript{122.} Maturana, \textit{Biology of Cognition}, p. 41.
of linguistics is the extent to which language is pervaded with implicit reality constructs (see page 29). Consequently, a complete understanding of notions which are embedded in our language will only result from a conceptual leap beyond ordinary language—a leap, presumably, into a tacit communication domain, or into a new consensual domain, in which new linguistic interactions are undertaken (words are re-defined, or new words are originated, for example).

As Maturana has pointed out, "We are used to talking about reality orienting each other through linguistic inter-
actions to what we deem are sensory experiences of concrete entities, but which have turned out to be, as are thoughts and descriptions, states of relative activity between neurons that generate new descriptions."\textsuperscript{123} It is important, then, to recognize that describing a new notion of "reality" is an endless recursive process. Every orientation modifies the orienter as well as the orientee. Thus every linguistic inter-
action as it represents a behavioral transformation (e.g., a new behavior based on a new orientation toward "reality") brings about behavioral transformation through the process of transformation itself. Likewise, change in the nervous system results from interaction between topography (the embodiment of change) and functioning (changing) as a process.

The purpose of this thesis is to change the reader...

\textsuperscript{123} Maturana, \textit{Biology of Cognition}, p. 84.
RECAPITULATION

Reality involves the recognition of patterns of contextual relationship. Patterns are our descriptions of changes; that is, historical transformations. Recognition involves the relationship process including substructure, metastructure and superstructure (the self, the non self, and the "actualized appearance of observational relations"). We (that is, organisms in the context which enables us to engage in those behaviors in which we are now engaged) describe recognized patterns of relations in our experience and regard our descriptions as sensory experiences of concrete, "external" entities. Furthermore, many of our ordinary notions about the perception of reality are based on the assumption that these "external" entities are passively received by organisms and statically retained by the "internal" structure of the nervous system. This notion, psychoneural isomorphism pervades our descriptions. In fact, our everyday language, as a descriptive metaphor for neural activities, is so saturated with this type of implicit reality construct (e.g., in its dualistic subject-object orientation) that it becomes difficult to fully understand that which is being described, and successfully avoid confusing the metaphor with the reality.

Certain models (descriptions) of the nervous system provide a basis for a more thorough understanding of the notion of psychoneural isomorphism. The probability computer model, the holophonic model, and the non-linear system model, for example, orient us to important aspects of actual nervous system operation. A composite model (utilizing aspects of all three models) points out incongruities between the notion of "internal/external" and the actual topography and functioning of the nervous system. Such a composite model describes these significant aspects of the nervous system: a) efferent posturing of the organism, b) afferent configuring of physical and non-physical interactions, c) the overall functional integrity (non-local organization) of the system, d) the real-time of organism's interactions e) the interaction of the system with relations rather than representations, and f) the corruption of 'input' information as observed in 'output'. Not only do these characteristics of nervous system activity constitute a refutation of the "internal/external" distinction, but furthermore, they provide the basis for a new stance with regard to the perception of reality (including, for example, the need for a re-definition of most of our terms for perceptual phenomena, e.g., 'hallucination', 'image', etc.).

Because we orient one another to important aspects of our experience within the consensual linguistic domain, and
because this domain includes misperceptions generated by implicit reality notions, and the possible mistaking of description for reality, it is necessary to shift our focus/locus relationship to another context, one in which the linguistic domain may be regarded as object. This shift involves a new consensual structuring of our descriptions. This is the extent to which I am able to orient the reader with regard to new domains of interaction. As Wittgenstein has stated, "There are, indeed, things that cannot be put into words. They make themselves manifest. They are what is mystical."125 Finally, "What we cannot speak about we must pass over in silence."126


126. Ibid.
APPENDIX
(IMPLICATIONS)

The linguistic domain provides the context in which one organism may orient another organism to the existence of an object within the parallel experiences of both organisms. One form of orienting behavior is the set of relations we have historically referred to as art. Art has been regarded as including relationships between humans we call artists, physical phenomena we call art objects and other humans we call viewers, (or perceivers, audiences, etc.). One further characteristic of art, as it has conventionally been described, is that it is said to involve a sub-class of behaviors known as "creative behaviors" which are, purportedly, distinguishable from other sub-classes of behavior.

Our notions of what constitutes art have gone through a long historical transformation and criteria for distinguishing art relationships from other aspects of experience have changed accordingly. For example, our descriptions of what constitutes an artist have varied according to prescriptive cultural127 behavior expectations (including ethical and

127. The terms "cultural" and "culture" should be taken in the most general sense. "Culture" here refers more to a milieu or an ecological niche in which interactions take place than to an exclusively human societal structure.
esthetic dictates), which likewise vary in space and time. Consequently, in those instances where one culture is, because of some new technology, apprised of the existence of another culture, re-evaluations of criteria for distinguishing artists are likely to occur. (The acceptability of "primitive," or naive artists as artists illustrates this situation.) Similarly, our descriptions of what comprises art objects have undergone transformations. The given technology of a culture conditions considerations of the nature of art objects. (For example, the function or use of an object in one culture may be regarded as purely utilitarian, while in another milieu it is considered an art object.) Furthermore, new technological developments have the capacity to change a culture's notion of art object as distinct from other objects. Likewise, our determinations of what constitutes viewers of art objects have undergone changes both as a result of contact with new kinds of viewers (new cultures) and new ways of viewing (new technologies). Finally, our descriptions of "creative behaviors" have changed as a result of our awareness of new categories of behaviors (as we observe new cultures), and our new possibilities of extending and synthesizing behavior (through

128. "Technology" is used here to refer to a wide variety of means utilized by organisms to expand their behavioral possibilities.
our expanding technologies).

Let us then examine more carefully the implications of the new stance with regard to "reality" described in this thesis, for furthering not only change in the reader, but change in our notions about art as well.

Let us first consider the notion of the artist. In terms of the stance outlined in this thesis, the artist can be seen as an organism interacting with relations in his own cognitive domain. When we as observers tend to identify the artist as an entity separate from his behaviors (a behaving organism), we neglect the fact that it is through his behaving that we are aware of his existence in a given context. The organism, the behaving, and the context are inextricably related, and it is only within the observational domain that we describe certain organisms as artists. The implication here is that our notion of the artist as a static, discernable, entity is unrealizable, and therefore, new descriptions of the artist must be generated. "An artist [italics mine] is not an isolated system. In order to survive...he has to continuously interact with the world around him. Theoretically, there are no limits to his involvement."129 Since Marcel Duchamp's first unassisted readymade, the artist has become less and less a distin-

guishable feature of art. The artist's involvement in and with larger milieus (group situations) demonstrates a growing sense of the irrelevance of individualized, separable, describable identities. A further implication of the stance suggested in this thesis is that artists are not discernable as exclusively human; that is, artists cannot be described according to existing criteria such as 'humanness' since these criteria have become inadequate in the context of continuing technological development. Consequently, a computer, a chimpanzee, or some other non-human system is as likely to be able to pass the 'Turing test for artists' as is any given human organism.  

Let us now consider the notion of the art object. The implication of the new stance described in this thesis with regard to the art object, is simply that no such object is observable apart from the context in which it occurs. Art contexts provide us with the possibility of apprehending art objects. But the context itself can be viewed as object, and furthermore, processes can be and are viewed as objects. Twentieth-century physics has demonstrated that the object


is a changing, flowing process (the observation of which alters the process) rather than a static 'thing'. Artists, as they are attuned to an awareness of art objects as discernable entities only because of their context, may begin to manipulate the types of objects which are placed in an art context and which become, thereby, art objects. (Duchamp's readymades are, again, a prophetic example of this phenomenon.) Furthermore, as the technology expands the awareness of the artist he may become more interested in new types of orientations ("media", techniques, etc.) Thus, "any form of energy can or may be used to convey art information...the sender or carrier is in fact a secondary problem to that of formulating a significant reason for its use."132 This awareness of the wide range of materials and non-materials open to the artist may result in new concerns; not with hardware but with "software significance for effecting awareness of events in the present."133

The implication of the stance presented here for the notion of the viewer of the art object is that it is difficult to separate the viewer from the viewing process, and furthermore, within the viewing process it is difficult to separate viewing "external" states from viewing "internal"

states. **Viewers** are (as are **artists**) integrally related to the art object since they perceive it (an active process) by regarding it within an art context. **Viewers** do not passively soak up impressions from physical entities "external" to themselves, but participate in the viewing process; that process through which an **art object** is 'realized.' **Viewers** interacting with relations in their own cognitive domains in real time, begin to influence the operations of **art objects** (as real time systems themselves).\(^{134}\) Furthermore, viewing is not an exclusively human activity. Our expanding technology has provided the possibility of sophisticated forms of pattern recognition by machines, for example. If a Turing test is to be applied to various pattern recognizers, certain computer programs may be able to pass the test. **ELIZA\(^{135}\)** for example, utilizes extensively the principle of contextual recognition to carry on conversations, and even client-centered therapy with human interlocutors. Technologically developed pattern recognition systems need not be regarded as passive receivers any more than humans, but can engage in seeking behaviors,\(^{136}\) learning,

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and varying degrees of selective 'attention'. Viewers who become aware of the relative difficulties inherent in distinguishing "internal" states from "external" states may come to regard nervous system relations themselves as viewable. Furthermore, as notions of "internal" and "external" control become less relevant, viewers may develop techniques for sophisticated modification of their own states (including so-called autonomic functions). Also, as new ways of creating experiences (electrical, chemical, etc.) become accessible, viewers are likely to change in terms of existing patterns of response. Thus, new, previously unrecognized 'sense modalities' may be revealed, and viewers may change with regard to ways of perceiving reality. Thus, "the art experience attaches itself less and less to canonical or given forms but embraces every conceivable experiential mode, including living in everyday environments." 137 And thus, art becomes "temporal immersion in a continuous contextual flow of communicated experiences." 138

The stance with regard to reality presented in this paper also has important implications for the notion of "creative behavior", often regarded as the means by which art objects are made. The implication here is that "creative

behavior" is difficult for observers to isolate. "Creative behaviors," which of course are not exclusively artists' behaviors, are often regarded as those behaviors where there is no "extrinsic reinforcement." But what appears to the observer as "intrinsically reinforcing" behavior (behavior in which the behaving itself seems to maintain the ongoing behavior and increase the probability that it will recur) may not be "intrinsically reinforcing" for the behaving organism. As we have established, the temporal duration of an event as seen by an observer differs from the real time of the organism's interactions. Thus, what appears to the observer as "creative behavior" may simply be behavior for which the reinforcement is delayed (or for some other reason is not perceivable by the observer). Making art becomes more and more a real time process in which a wide range of experiences in the real time of the artist's interactions may enter into and influence the making itself. Furthermore, in real time the notion of presentation may emerge as more meaningful for artists, who have historically been engaged in various re-presentational situations. Another implication with regard to the 'making' of art is that as artists begin to recognize the difficulties involved in distinguishing "internal" control from "external" control they may cease to be concerned with the form of "external" control over objects which we have traditionally regarded
as craft. Finally, another implication of the stance we have discussed is that artists may begin to regard art itself as no less a system of interactions than any other (human or otherwise) and consequently, may begin to focus on the ultimate reflexiveness (circularity) of the system. As this realization emerges, art will be seen more and more as "a self-metaprogram which, on a long-term basis, reorganizes the goals of the art impulse."\textsuperscript{139} Or, stating it more succinctly, "Art is the definition of art."\textsuperscript{140}

\textsuperscript{139} Jack Burnham, "Real Time Systems," p. 49.

BIBLIOGRAPHY


Kamiya, Joe; Spiiker, Bert; Calloway, Enoch; and Yeager, Charles L., "Visual Evoked Responses in Ss Trained to Control Alpha Rhythms." Psychophysiology. Vol. 5, no. 6, 1969, pp. 683-695.


