Introductory Tutorial: Autopoiesis & Enaction

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This introductory tutorial is designed to give you a brief overview of *autopoietic theory* -- the term I use to denote the work of Chilean biologists Humberto R. Maturana and Francisco J. Varela. The following sections each provide a summary overview of a key concept. The literature citations are a small subset of the comprehensive bibliography available at this Web site.

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The Chronology of Maturana and Varela's Work

Maturana picture 1

During the 1960's, the Chilean biologist **Humberto R. Maturana**

began to question the prevailing notions of cognition. The further he proceeded, the more he realized that he would have to completely redefine the phenomenology of the living in terms of the organism itself, so as to avoid superfluous and confusing abstractions. This in turn forced him to define living systems. By 1970, he had outlined a novel view from which living systems were defined in terms of their processual configuration.

Varela picture 1

Francisco J. Varela was a student and colleague of Maturana's. Together, they formalized this new perspective into a theoretical framework which claimed the essential feature of living systems was *autopoiesis* -- a system's self-production of the components realizing its *organization* (its definitive processual configuration). A living system was any system exhibiting autopoiesis in the physical space.

Through the early 1970's, Maturana and Varela extended and refined their theory in a series of papers. Two of the key articles ('Biology of Cognition' [Maturana, 1970] and 'Autopoiesis: The Organization of the Living' [Maturana & Varela, 1973]) were reprinted together in a 1980 volume entitled *Autopoiesis and Cognition: The Realization of the Living*. In the mean time, Varela had published a 1979 volume entitled *Principles of Biological Autonomy*, which extended the scope and depth of the earlier papers. These two books are the cornerstones of the theoretical literature in this field.

During the 1980's, Maturana and Varela collaborated to produce *The Tree of Knowledge* -- an overview of their ideas for general consumption. This book has served to introduce a wide (and growing) audience to their work. Most recently, Varela (in collaboration with Evan Thompson and Eleanor Rosch) has outlined an agenda for an *enactive cognitive science* in the 1991 book *The Embodied Mind*.

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Cognition as a Biological Phenomenon

Maturana's early experimental work in neurophysiology and perception (Maturana et.al., 1960; Maturana et.al., 1968) led him to question information-theoretic notions of cognition. The theory he subsequently created and refined with Varela was originally intended to address issues theretofore subsumed under studies of 'cognition' and/or 'perception'. The theory's scope has not remained limited to those issues. It builds from its cognitive base to generate

implications for (among other things) epistemology, communication and social systems theory. These additional foci have traditionally been placed under the jurisdictions of (respectively) philosophy, linguistics, and sociology. Why, then, should we consider them a subject of concern for a biologist? Maturana's direct reply is that 'Cognition is a biological phenomenon and can only be understood as such; any epistemological insight into the domain of knowledge requires this understanding.' (Maturana & Varela, 1980, p. 7)

As a biological phenomenon, cognition is viewed with respect to the organism(s) whose conduct realizes that phenomenon. In autopoietic theory, cognition is a consequence of circularity and complexity in the form of any system whose behavior includes maintenance of that selfsame form. This shifts the focus from discernment of active agencies and replicable actions through which a given process ('cognition') is conducted (the viewpoint of cognitive science) to the discernment of those features of an organism's form which determine its engagement with its milieu.

This orientation led to a systematic description of organisms as self-producing units in the physical space. The principles and definitions making up this systematic schema will be termed autopoietic theory's **formal aspects**. Deriving from this formal foundation a set of operational characteristics (e.g., self-regulation; self-reference), Maturana and Varela developed a systemic explanation of cognition and a descriptive phenomenology. The principles and definitions making up this systemic description will be termed autopoietic theory's **phenomenological aspects**. Autopoietic theory has been applied in diverse fields such as software engineering, artificial intelligence, sociology, and psychotherapy.

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The Observer

'Everything said is said by an observer'.
(Maturana & Varela, 1980, p. xix)

Maturana's initial work on cognition emphasized individual living systems. As a result, autopoietic theory has as its foundation the manner in which living systems address and engage the domain(s) in which they operate. This orientation subsumes the manner in which autopoietic theory addresses itself (as a scientific theory) and all other phenomena. A cognizing system engages the 'world' only in terms of the perturbations in its nervous system, which is **'operationally closed'** (i.e., its transformations occur within its bounds). To the extent that the nervous system recursively interconnects its components (as in our brains), the organism is capable of generating, maintaining and re-engaging its own states as if they were literal re-presentations of external phenomena. Such states are 'second-order' in the sense that they are derivative from, rather than literal recordings of, experience. These states are called **descriptions** in autopoietic theory, and an organism operating within the realm of its

descriptions is an **observer**. The primary such operation is making distinctions which cleave the observing system's environment into 'object' and 'other'. In Maturana's own words:

> 'An observer is a ... living system who can make distinctions and specify that which he or she distinguishes as a unity, as an entity different from himself or herself that can be used for manipulations or descriptions in interactions with other observers.'
> (Maturana, 1978b, p. 31)

The observer is one of the key concepts in autopoietic theory, because:

> 'Observing is both the ultimate starting point and the most fundamental question in any attempt to understand reality and reason as phenomena of the human domain. Indeed, everything said is said by an observer to another observer that could be him- or herself.'
> (Maturana, 1988, p. 27)

The fundamental operation in observing is that of **distinction** -- '...the pointing to a unity by performing an operation which defines its boundaries and separates it from a background.' (Maturana, 1975, p. 325) Through the recursive distinguishing of entities through action, the observer is '...able to operate as if external to (distinct from) the circumstances in which he finds himself.' (*Op. cit.*, p. 315) However, the observer is not actually standing apart from those circumstances. This is due to the fact that the entire and the only domain in which he/she operates is that of his/her closed (self-interconnected) nervous system. The nervous system's connectivity and closure permit interactions among its own states at time t1 to determine its states at time t2. This circular interaction allows for '... infinite recursion with continuous behavioural change.' (*Op. cit.*, p. 324)

The notion of the observer circumscribes all enquiry and all discussion. The precise form(s) and function(s) by which systems are distinguished are unavoidably imposed by whatever observer is addressing them. The qualification of any observation with respect to the vantage point of a given observer makes autopoietic theory inherently relativistic with respect to the person of the observer. Second, the resulting qualification of any set of observations over time with respect to the vantage events of a given observer makes autopoietic theory inherently relativistic with respect to the history of the observer. Third, since shared or collectively negotiated descriptions of experience (e.g., recollections [past], consensus [present], plans [future]) are qualified with respect to the interactions among given observers, autopoietic theory is inherently relativistic with respect to the persons of interacting observers and their joint history of interactions.

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Fundamental System Attributes:

Organization and Structure

Organization

Systems cannot be defined by simply enumerating or tracing the layout of their constituent elements. The definitive attribute of a systemic entity is the set of inter-component relationships which (a) outline its form at any given moment and (b) serve as the core 'identity' which is maintained in spite of dynamic changes over time. In autopoietic theory, this set of defining relationships is termed a system's **organization**.

> 'The relations that define a machine as a unity, and determine the dynamics of interactions and transformations which it may undergo as such a unity, constitute the organization of the machine.'
> (Maturana & Varela, 1980, p. 77)

Maturana (1975) notes 'organization' comes from the Greek and means 'instrument'. By using this word for the essential, defining character of a system he focuses attention on '...the instrumental participation of the components in the constitution of the unity.' (*Op. cit.*, p. 315) It is the organization of a system which defines its identity, its properties as a unity, and the frame within which it must be addressed as a unary whole.

Structure

In effect, a system's organization specifies a category, within which there may be many specifically-realized instantiations. Specific systemic entities exhibit more than just the general pattern of their organization -- they consist of particular components and relations among them. A systemic unity's organization is specifically realized through the presence and interplay of components in a given space. These comprise the unity's **structure**. Maturana (1975) points out the word 'structure' comes from the Latin meaning 'to build'. He employs this allusion in assigning to this label '...the actual components and ... the actual relations which these must satisfy in their participation in the constitution of a given unity.' (*Op. cit.*, pp. 315-316) Structure does not determine the overall character of a unity; it determines only '...the space in which it exists and can be perturbed.' (*Ibid*.)

A unity may change structure without loss of identity, so long as its organization is maintained. Maturana and Varela's distinction between organization and structure provides a basis for sorting out descriptions of systems into their abstract and concrete aspects. Formally speaking:

> 'The organization of a machine (or system) does not specify the properties of the components which realize the machine as a concrete system, it only specifies the relations which these must generate to constitute the machine or system as a unity. Therefore, the organization of a machine is independent of the properties of its

> components which can be any, and a given machine can be realized in many different manners by many different kinds of components. In other words, although a given machine can be realized by many different structures, for it to constitute a concrete entity in a given space its actual components must be defined in that space, and have the properties which allow them to generate the relations which define it.'
> (Maturana & Varela, 1980, p. 77)

A 'nitty-gritty' illustration of the distinction is given in the 1987 book *The Tree of Knowledge*:

> '...in a toilet the organization of the system of water-level regulation consists in the relations between an apparatus capable of detecting the water level and another apparatus capable of stopping the inflow of water. The toilet unit embodies a mixed system of plastic and metal comprising a float and a bypass valve. This specific structure, however, could be modified by replacing the plastic with wood, without changing the fact that there would still be a toilet organization.'
> (Maturana & Varela, 1987, p. 47)

The organization / structure dichotomy is graphically illustrated in the work of the 16th Century Italian painter Giuseppe Arcimboldo, who devised remarkable portraits in which the faces are composed of (e.g.) fruits, vegetables, seafood, etc. His fanciful art realized a discernible facial 'organization' through a 'structure' of novel components. Below is his portrait (of Emperor Rudolph II) entitled *Vertumnus*. How do you recognize this pile of fruits and vegetables (the structure) as a face? Because of its essential organization, which is illustrated as a schematic pattern.

Organization of the face Arcimboldo's 'Vertumnus' (detail)

Maturana and Varela's complementary distinction between organization and structure is very useful in delineating and analyzing systems' form and function -- for example, describing enterprises as having generally invariant form in spite of specifically changing components.

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Autopoiesis and Autonomy

Autopoiesis

Maturana and Varela's central concept is that of **autopoiesis**. According to Maturana (Maturana and Varela, 1980, p. xvii) the term was coined around 1972 by combining the Greek **auto** (self-) and **poiesis** (creation; production). The concept is defined formally as follows:

'An autopoietic system is organized (defined as a unity) as a network of processes of production (transformation and destruction) of components that produces the components that:

1. through their interactions and transformations continuously regenerate and realize the network of processes (relations) that produced them; and
2. constitute it (the machine) as a concrete unity in the space in which they [the components] exist by specifying the topological domain of its realization as such a network.'

(Varela, 1979, p. 13)

Any unity meeting these specifications is an autopoietic system, and any such autopoietic system realized in physical space is a living system. The particular configuration of a given unity -- its **structure** -- is not sufficient to define it as a unity. The key feature of a living system is maintenance of its **organization**, i.e, preservation of the relational network which defines it as a systemic unity. Phrased another way, '...autopoietic systems operate as homeostatic systems that have their own organization as the critical fundamental variable that they actively maintain constant.' (Maturana, 1975, p. 318)

Autopoietic theory is the primary (perhaps the only...) example of a definition for life which is framed purely with respect to a candidate system in and of itself. If you go back and check most definitions (e.g., in a biology text), you are likely to find nothing more coherent than a list of features and functional attributes (e.g., 'reproduction', 'metabolism') which describe what living systems do, but not what they are. For this reason, autopoiesis has become a topic of interest in the recent field of **artificial life (Alife)**

Autonomy

During the mid- to late 1970's, Varela expanded on autopoietic theory's original formalizations to delineate the systemic attribute of **autonomy**, of which autopoiesis is a subset. Autonomous systems are:

'...defined as a composite unity by a network of interactions of components that (i) through their interactions recursively regenerate the network of interactions that produced them, and (ii) realize the network as a unity in the space in which the components exist by constituting and specifying the unity's boundaries as a cleavage from the background...'
(Varela, 1981, p. 15)

The difference between autonomy and autopoiesis is that autopoietic systems must produce their own components in addition to conserving their organization. As we shall see later, this difference has played a large role in the debates over the extent to which social systems can be characterized as autopoietic.

This more general class of autonomous systems are defined by their **organizational closure**:

> 'That is, their organization is characterized by processes such that
>
> 1. the processes are related as a network, so that they recursively depend on each other in the generation and realization of the processes themselves, and
> 2. they constitute the system as a unity recognizable in the space (domain) in which the processes exist.'
>
> (Varela, 1979, p. 55)

It is important to note that this property of 'closure' does not make autonomous systems 'closed' in the classic cybernetic sense of 'isolated from the environment; impervious to environmental influence'. 'Closure' doesn't mean autonomous systems are unresponsive; it only means that their changes of state in response to changes in their medium are realized and propagated solely within the network of processes constituting them (as they are defined). The difference has more to do with the way a system is defined than how that system (once defined) operates. A fuller explanation of this point can be obtained in Varela (1979).

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Domains and Spaces

Another key concept in Maturana and Varela's writings is **domain**. They use the term generally to connote a 'realm' or 'sphere' circumscribing: (1) the relations among observed systems and the unities (medium) with which they can be observed to engage (e.g., phenomenological domain) or (2) the foregoing plus all potential states of relation and/or activity among the given unities (e.g., domain of interactions).

A **domain** is a description for the 'world brought forth' -- a circumscription of experiential flux via reference to current states and possible trajectories. Maturana and Varela define a number of domains in developing autopoietic theory's formal aspects into a phenomenological framework:

Domain of interactions
> '...the set of all interactions into which an entity can enter...' (Maturana & Varela, 1980, p. 8).

Domain of relations
> '...the set of all relations (interactions through the observer) in which an entity can be observed...' (*Ibid*.).

Phenomenological domain
> That set of actions and interactions '...defined by the properties of the unity

or unities that constitute it, either singly or collectively through their transformations or interactions.'(Varela, 1979, p. 46).

Cognitive domain
the set of '... all the interactions in which an autopoietic system can enter without loss of identity...' (Maturana & Varela, 1980, p. 136) An observer's cognitive domain circumscribes '...all the descriptions which it can possibly make.' (*Op. cit.*, p. 119).

Consensual domain
'.. a domain of interlocked (intercalated and mutually triggering) sequences of states, established and determined through ontogenic interactions between structurally plastic state-determined systems.' (Maturana, 1975, p. 316)

Linguistic domain
'...a consensual domain of communicative interactions in which the behaviorally coupled organisms orient each other with modes of behavior whose internal determination has become specified during their coupled ontogenies.' (Maturana & Varela, 1980, p. 120)

Maturana and Varela reserve the term **space** for the context in which unities are delineated -- a static referential background within which systems are defined. The only specific 'space' included in basic autopoietic theory is the **physical space** -- i.e., the world of matter and energy addressed by (e.g.) physical sciences. Both Maturana (e.g, 1978a) and Varela (1979) make allowance for other spaces in which unities can be discerned, but neither has explicitly delineated examples of autopoiesis in other spaces.

The notion of 'domain' is particularly useful in addressing actual systems (e.g., enterprises). By identifying, delineating, and sorting out the relevant domains in which enterprises (and their subcomponents) operate, analysis and planning are greatly facilitated.

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Structural Determination

Structural determination is the principle that the actual course of change in a systemic entity is controlled by its structure (the totality of specific components' individual and synergistic properties within the arrangement by which they constitute the system) rather than direct influence of its environment. The basic thrust of this principle is that the behavior of a system is constrained by its constitution, and potential system changes are circumscribed by:

- the system's range of potential structural transformations
- the set of potential perturbations impinging upon the system

Actual change is compensable behavior by the system's structure under perturbation by the environment and / or other systems in the course of its operation (cf. 'structural coupling', defined below). While a given perturbation may 'trigger' a change of system state, the particular change triggered is a function of the system's own organization and structure. Since 'structure' refers to any constitutive element of a discerned unity, structural determination concerns the manner in which observed (-able) phenomena are explained, not some formalized manner in which those phenomena objectively occur. As such, structural determination is an epistemological qualification, not a recourse to materialistic reductionism.

Structural determination should not be equated with strict causal determinism, in which all specific interactions are predetermined. It only means the space of all possible classes of interactions is determined. For example, in re-engineering an enterprise, the subject's structure does not uniquely predict its best new form. However, its structure circumscribes the range of new forms into which it can evolve without violating its organization (i.e., ceasing to exist as its current identity). Structural determination does not constrain the set of interactions in which a system can be observed to engage -- only the set in which that system can observe itself to be engaged:

> 'If the living system enters into an interaction not prescribed by its organization, it enters it not as the unit of interactions defined by this organization ... and this interaction remains outside its cognitive domain.'
> (Maturana, 1970, p. 6)

This point is important to enterprise analysts and (re-)engineers. To the extent they proceed as observers 'external' to everyday operations, they engage enterprises at the intersection of the enterprise's domain of operations and their own domain of analytical activity. The behavior analysts observe in this 'intersection zone' may not be either representative of, or defined in accordance with, the domain of enterprise operations in which it is ordinarily realized.

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Structural Coupling

Given the principle of structural determination, interaction among systems is explained as '...a history of recurrent interactions leading to the structural congruence between two (or more) systems' (Maturana & Varela, 1987, p. 75). **Structural coupling** is the term for structure-determined (and structure-determining) engagement of a given unity with either its environment or another unity. It is '...a historical process leading to the spatio-temporal coincidence between the changes of state..' (Maturana,1975, p. 321) in the participants. As such, structural coupling has connotations of both coordination and co-evolution. Structural coupling describes ongoing mutual co-adaptation without allusion to a transfer of some ephemeral force or information across the

boundaries of the engaged systems.

Case 1: A System Coupling with its Environment

> 'If one of the plastic systems is an organism and the other its medium, the result is ontogenic adaptation of the organism to its medium: the changes of state of the organism correspond to the change of state of the medium.'
> (Maturana, 1975, p. 326)

> '(T)he continued interactions of a structurally plastic system in an environment with recurrent perturbations will produce a continual selection of the system's structure. This structure will determine, on the one hand, the state of the system and its domain of allowable perturbations, and on the other hand will allow the system to operate in an environment without disintegration.'
> (Varela, 1979, p. 33)

Case 2: A System Coupling with Another System

> 'If the two plastic systems are organisms, the result of the ontogenic structural coupling is a **consensual domain**.'
> (Maturana, 1975, p. 326)

A consensual domain is therefore defined as '.. a domain of interlocked (intercalated and mutually triggering) sequences of states, established and determined through ontogenic interactions between structurally plastic state-determined systems.' (Maturana, 1975, p. 316). Because consensual domains are defined both by the structures of their participants and the history by which they came to exist, they are not reducible to descriptions framed only in terms of either:

> 'In each interaction the conduct of each organism is constitutively independent in its generation of the conduct of the other, because it is internally determined by the structure of the behaving organism only; but it is for the other organism, while the chain [of interactions] lasts, a source of compensable deformations that can be described as meaningful in the context of the coupled behavior.'
> (Varela, 1979, pp. 48 - 49)

Phrased in a slightly different way, the participating systems reciprocally serve as sources of **compensable perturbations** for each other. Such interactions are 'perturbations' in the sense of indirect effect or effectuation of change without having penetrated the boundary of the affected system. They are 'compensable' in the senses that (a) there is a range of 'compensation' bounded by the limit beyond which each system ceases to be a functional whole and (b) each iteration of the reciprocal interaction is affected by the one(s) before. The structurally-coupled systems ' will have an interlocked history of structural

transformations, selecting each other's trajectories.' (*Ibid*.)

The notions of 'structural determination' and 'structural coupling' provide a basis for analyzing enterprises and their operations in terms of their general and actual form (i.e., their organization and structure). This approach maintains a focus on the subject enterprise and minimizes counterproductive bias toward a priori allusions to abstractions such as 'information flows', 'market forces', and the like.

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Cognition as (Inter-)Activity

> 'Living systems are cognitive systems, and living as a process is a process of cognition.'
> (Maturana & Varela, 1980, p. 13)

We attribute **'cognition'** to a system when it is able to discriminate (in terms of response) among unit phenomena in its medium, synchronically (at a given moment) and diachronically (over time). The evidence for this 'cognition' is effectiveness of system behavior in response to the dynamics of its milieu. Today's dominant perspective on cognition is 'cognitivism' -- the idea that effective action is explainable in terms of algorithmic procedures for manipulating abstracted 'data' with respect to 'knowledge structures'. This approach is best known from the 'Human Information Processing' (HIP) school of psychology, artificial intelligence (AI), and the 'cognitive sciences' lying at their intersection. During the last decade, there has been a growing realization that cognitivism is at best a limited way of analyzing humans and their interactivity (cf. Winograd & Flores, 1986).

To Maturana and Varela, cognition is contingent on embodiment, because this ability to discriminate is a consequence of the organism's specific structure. From their perspective, cognition is what we attribute to systems exhibiting flexible and effective changes during **structural coupling**. A living system's organization circumscribes a domain of interactions within which activity relevant (and appropriate) to maintaining its autopoiesis is manifested.

> 'A cognitive system is a system whose organization defines a domain of interactions in which it can act with relevance to the maintenance of itself, and the process of cognition is the actual (inductive) acting or behaving in this domain.'
> (Maturana & Varela, 1980, p. 13)

Owing to this perspective, the object of cognition (e.g., the 'real world' or 'the environment') is necessarily qualified with respect to the observing organism. '[F]or every living system, its organization implies a prediction of a niche, and the niche thus predicted as a domain of classes of interaction constitutes its entire cognitive reality.' (Maturana & Varela, 1980, p. 11) In later writings, this

circumscribed 'cognitive reality' is usually termed a **cognitive domain** -- '... all the interactions in which an autopoietic system can enter without loss of identity...' or, with regard to the system as an observer, '...the domain of all the descriptions which it can possibly make.' (Maturana & Varela, 1980, p. 136)

Cognition in the autopoietic view is no more and no less than a living system's effective behavior within its domain of interactions. In other words, cognition is a matter of interacting in the manner(s) in which one is capable of interacting, not processing what is objectively there to be seen. In other words, Maturana and Varela do not address cognition in the currently conventional sense as an internal manipulation of extrinsic 'information' or 'signals', as the cognitivist viewpoint would have us believe:

> 'This would mean that such inputs or outputs are part of the definition of the system, as in the case of a computer or other machines that have been engineered. To do this is entirely reasonable when one has designed a machine whose central feature is the manner in which we interact with it. The nervous system (or the organism), however, has not been designed by anyone... (T)he nervous system does not 'pick up information' from the environment, as we often hear... The popular metaphor of calling the brain an 'information-processing device' is not only ambiguous but patently wrong.'
> (Maturana & Varela, 1987, p. 169)

A full exploration and analysis of Maturana and Varela's views on cognition lies well outside the scope of this brief overview. For now, it must suffice to say that their reinterpretation of cognition grounds cognitive activity in the embodiment of the actor and the specific context of activity. As such, autopoietic theory fits very well with current trends toward emphasizing 'contextualization' and 'auto-determination' studies of humans, their interactions, and their social systems. Varela *et al.* (1991) provide a recent extension of these principles into an **enactive cognitive science**.

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Languaging

Maturana (1978a) is the key source for autopoietic theory's account of linguistic interaction. Building from the tenets of structural determinism and structural coupling, he constructs a model of **languaging** -- activity in which interactors mutually orient themselves to each other and to a subject. In colloquial discussions generally (and cognitivism specifically), interpersonal communication is typically treated as a 'piping' of 'information' among conversants. This view presumes 'information' is a quantum commodity, and it shifts the focus of observation from interactors to a presumed commerce in this commodity. In their book *Metaphors We Live By*, Lakoff and Johnson describe this view as a 'conduit metaphor' for communication, as illustrated below.

Conduit metaphor for communication

The Conduit Metaphor for Communication (from Whitaker, 1992)

Cognitivistic approaches conventionally treat this commerce as 'instructive interactions' (Maturana, 1978a) -- interactions in which the 'receiver' adopts a state determined by the state of the 'sender' as projected via the 'message'. This view of language concentrates on '...a denotative system of symbolic communication, consisting of words that denote entities regardless of the domain in which these entities may exist.'(*Op. cit.*, p.50) Such an approach overlooks the fact that 'Denotation ... requires agreement -- consensus for the specification of the denotant and the denoted.' (*Ibid.*)

In analyzing actual communication, the prevailing approach is very problematical. Communication is of interest to the extent of what happens with or to the person 'receiving' it ('persons' in the case of reciprocal dialogue or one-to-many broadcasting). Because a quantum 'information' commodity is not defined with regard to the structure of the interactor(s), focusing on the 'message' blinds an observer (e.g., an enterprise analyst) to the actor and her activity during conversation. This leaves the analyst to wonder about cases in which apparently clear-cut 'messages' were not 'instructive' -- i.e., didn't induce the effect of their content. For example, meeting participants are often operating with very different views of topics, intentions, and outcomes. This lack of consensual orientation is illustrated below.

Illustration of ambiguity among conversants

Ambiguity in Communication (from Whitaker, 1992)

Maturana views language as the archetypal illustration of a human consensual domain. Linguistic interaction is a venue for action, coupling the cognitive domains of two or more actors. This is reflected in Maturana's preference for discussing **languaging** (the act) as opposed to 'language' (a symbolic schema). The primary function of linguistic interaction is therefore not conveyance of 'information quanta', but the mutual orientation of the conversants within the consensual domain realized by their interactivity. 'Communication' becomes a matter of mutual orientation -- primarily with respect to each other's behavior, and secondarily (only via the primary orientation) with respect to some subject. This is extremely important for delimiting the constraints on an observer's (e.g., an enterprise analysts') analysis of communicative interactions. In today's conventional (e.g., cognitivistic) approaches, such interaction is described as a semantic coupling -- a process by which each of the observed interactors computes the appropriate response state from some informative input from the other. Maturana warns that this is not warranted ...

> '(a) because the notion of information is valid only in the descriptive domain as an expression of the cognitive uncertainty of the observer, and does not represent any component actually operant ... and (b)

> because the changes of state of a [structurally] determined system, be it autopoietic or not, are determined by its structure, regardless of whether these changes of state are adequate or not for some purpose that the observer may consider applicable.'
> (Maturana, 1975, p. 322)

This moves linguistic interaction to a conceptual base whose elements apply to a much broader range of actors and interactions than symbolic data. The structural coupling of the participating organisms is the only operative element -- all other items treated in descriptions of linguistic behavior are secondary. How, then, can one account for the seemingly secure framework within which we ordinarily consider conversation to occur -- shared lexicons, objective meanings, and syntactic conventions? Maturana claims: (1) such a question is biased in its presumption that such a framework objectively exists, and (2) such regularities are imposed by an observer:

> 'If recursion is possible in a particular kind of behavior ... a closed generative domain of behavior is produced. ... What is peculiar about a language, however, is that this recursion takes place through the behavior of organisms in a consensual domain. In this context, the superficial syntactic structure or grammar of a given natural language can only be a description of the regularities in the concatenation of the elements of the consensual behavior. ...This superficial syntax can be any, because its determination is contingent on the history of consensual coupling ... (T)he 'universal grammar' of which linguists speak as the necessary set of underlying rules common to all human natural languages can refer only to the universality of the process of recursive structural coupling.'
> (Maturana, 1978a, p. 52)

The reclassification of communicational behavior from conceptual commerce to mutual orientation expands the range of behaviors we may consider as 'communicative'. The autopoietic view of language is not constrained to coded symbols for the manner in which interactors couple. 'The richness attained by a language ... depends necessarily both on the diversity of behaviors that can be generated and distinguished by the organisms that participate in the consensual domain.' (*Op. cit.*, p. 51) By disengaging interaction from lexical reference and grammatical performance, the autopoietic model implicitly allows for all manner of non-verbal or extra-verbal signalling -- a scope more akin to semiotics than mainstream linguistics.

By linking linguistic interaction with structural coupling, the context for signification (determination of meaning) is unified with the context of the interaction. This unification 'grounds' context in the individual's experience, rather than leaving it as a receding horizon of meta-symbolic determinants. This in turn unifies the two senses of 'context'-- determinant of linguistic 'meaning' and relevant situational background. This affords autopoietic theory a sound basis for addressing the context-dependent aspects of actual interactions.

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Enaction

Autopoietic theory's formal tenets provide us with novel means for explaining cognition. However, the ongoing processual flow of cognition is not captured, even though (as a process) its basic mechanisms are described. These mechanisms are outlined with regard to a space of realization and the manifest topology by which an autonomous system is distinguished from the ambient. The next step is to delve into the observing system's phenomenology -- 'the domain of all the phenomena defined in the interactions of a class of unities' (Maturana & Varela, 1987, p. 253, emphasis added). To address the phenomenology of everyday life one must shift the focus to those interactions through which lived experience is realized.

In their 1991 book *The Embodied Mind*, Varela, Evan Thompson and Eleanor Rosch bring phenomenological concerns into the world of cognitive science. Their goal is to incorporate everyday experience into the scope of studies which have heretofore addressed cognition solely in terms of disembodied rational processes, circumscribed by abstract conceptual elements purported to mirror an objective milieu. Their enquiry begins with noting a **fundamental circularity** affecting all such investigations -- the mind reflecting on the world is itself dependent on its structure (its biological base), and knowledge of that structure is mediated by the mind. Another way to describe this is that any categorical statement about 'the world' and / or 'the mind' is made by an enquirer (observer), who remains outside the scope of the enquiry. This 'standing apart' excludes the observing enquirer from the phenomenon she studies, even though her enquiry is conducted on the basis of that selfsame phenomenon.

Varela *et al.* proceed from the assumption that experience necessarily predates and underpins enquiry. To overcome the 'fundamental circularity' requires an explanation for how lived experience forms the foundation for description of mind, world (as experienced), and the relation(s) between them -- not the other way around. The current obstacle to such an explanation is the long-standing philosophical war over the mind-body problem. Varela *et al.* redefine the focus of this debate by saying, '...the mind-body question need not be, What is the ontological relation between body and mind, regardless of anyone's experience? -- but rather, What are the relations of body and mind in actual experience ... how do these relations develop, [and] what forms can they take?' (p. 30). These relations are to be discerned with respect to the course of experiential **enaction** because '...the body and mind relation is known in terms of what it can do.' (p. 30).

Maintaining a focus on experience as action allows inspection and reflection on the manner in which 'mind' and 'body' reciprocally engage to consummate experience. The authors reject the Cartesian dualism which has forced Western philosophers to choose between either mind or body as the fundament for the

other prior to addressing experience. They term this malaise *Cartesian anxiety* -- an overwhelming desire for some fixed ontological reference point, and a corresponding dread of the chaos presumed to be the only alternative. This fetish for fixity motivates acceptance of any 'fundament' for philosophizing, be it the world or a model objectively mirroring it (realism), or the subject's inner consciousness (idealism). Such binary absolutism delineates the dilemma for cognitive science -- these extremes '...both take representation as their central notion: in the [realist] case representation is used to recover what is outer; in the [idealist] case it is used to project what is inner.' (p. 172)

Varela, Thompson and Rosch then outline what they see as the positions evidenced in the dominant cognitive science paradigm (**cognitivism**) and the recently ascendant interest in **connectionism**. They outline their **enactive perspective** as a third alternative, contrasted with the other two. A summary comparison of the three perspectives is given in the table below.

THE THREE TRADITIONS OF COGNITIVE SCIENCE

(Based on Varela, Thompson & Rosch, 1991)

	COGNITIVISM	**EMERGENCE (Connectionism)**	**ENACTIVE**
METAPHOR FOR MIND:			
	Digital computer	Parallel distributed network	??? inseparable from experience and world
METAPHOR FOR COGNITION:			
	Symbol processing	Emergence of global states	Ongoing interaction within the medium
THE WORLD IN RELATION TO US:			
	Separate Objective	Separate Objective	Engaged 'Brought forth'
	Representable (in symbols)	Representable (in patterns of network activation)	Presentable (through action)
MIND VS. BODY/WORLD:			
	Separable	Separable	Inseparable
	Cartesian dualism -- (mind and body hermetically sealed from each other)	Epiphenomenal dualism-- (mind related to body and world via emergence)	Phenomenology -- (mind and world enacted in history of interactions)
EXPONENTS:	(cf. Figure 1.1, p. 7, in Varela, Thompson & Rosch (1991))		
	Simon, Newell, Chomsky,	Rumelhart, McClelland,	Maturana, Lakoff,

The cognitivist and connectionist paradigms remain subject to the theoretical limitations outlined earlier. As a result, Varela, Thompson and Rosch suggest creation of an **enactive cognitive science** based on three principles:

- Addressing commonsense action through '...treating context-dependent know-how not as a residual artifact that can be progressively eliminated by the discovery of more sophisticated rules but as, in fact, the very essence of creative cognition.' (p. 148)
- Embracing the hermeneutic viewpoint that '...knowledge depends on being in a world that is inseparable from our bodies, our language, and our social history -- in short, from our embodiment. ' (p. 149)
- Carrying forth autopoietic theory's idea of cognition as interaction / coupling, where '...knowledge is the result of an ongoing interpretation that emerges from our capacities of understanding ... rooted in the structures of our biological embodiment but ... lived and experienced within a domain of consensual action and cultural history.' (p. 149) This is the position of cognition as *embodied action* -- where '..cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities ... themselves embedded in a more encompassing biological, psychological, and cultural context.' (p. 173).

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Summary

Autopoietic theory provides a rigorous theoretical basis for addressing people and the social systems in which they participate. Because the theory proceeds from formal specifications on systemic unities, its tenets can conceivably be applied to both. Owing to the extent of Maturana and Varela's expansion of the core concepts to describe a phenomenology of living systems, the theory's scope is relatively broad. This permits researchers to apply its principles across a broader range of subject phenomena than is the case for other current approaches. Because it is rooted in a formal analysis of living systems and cognition, the theory can support research focusing on individual subjects and their activities within an enterprise (e.g., workflow analyses, human factors / HCI analyses of specific information system users). Because the theory includes an explanation for linguistic interaction, it can support research focusing on enterprise social interactions and communications (e.g., ethnographic studies; qualitative research). The more recent focus on *enaction* initiated in *The Embodied Mind* has moved autopoietic theory's focus forward from formal models to dynamic phenomenology.

Having completed this overview, it should be clearer to you how autopoietic

theory intrinsically supports attention to the three emergent themes in current studies of cognition, interaction, and social systems: systemic perspective, auto-determination, and contextualization. The first occurs by definition, the second by focus, and the third by the manner in which Maturana and Varela lay out the phenomenological aspects of the theory.

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But Wait -- There's More !!

There's much more to these topics than I can present in this space, and there are many more topics in the area of autopoietic theory. If you'd like to explore autopoietic theory in more depth, check into the research resources I've compiled and made available at this Web site.

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