Humberto Maturana and Francisco Varela's Contribution to Media Ecology: Autopoiesis, The Santiago School of Cognition, and Enactive Cognitive Science

Ronan Hallowell

This paper provides an overview of the major body of work in the biology of cognition produced by the Chilean biologists Humberto Maturana and Francisco Varela. In addition to a review of their work together, Varela's "enactive" approach to cognition is discussed. Insights from these studies are related to the field of media ecology. In their early work together Maturana and Varela developed the idea of "autopoiesis" (self- production) as the primary feature that distinguishes living things from non-living things. From their theory of autopoiesis in biology, they develop a naturalistic, non-transcendental and observer-dependent interpretation of cognition, language, and consciousness. They argue against any absolutely objective world; instead they claim that we bring forth a world with others through the process of our living in human created worlds that arise through language and the coordination of social interaction. Implications of this view for media ecology are considered.

Introduction

Many of Maturana and Varela's concepts are controversial and not widely accepted in mainstream science; nonetheless, their ideas have been widely debated and have been influential in a variety of disciplines (Thompson, 1991; Margulis & Sagan, 1997; Jantch, 1980; Luhmann, 1995; in t'Veld, Schaap, Termeer, & van Twist, 1991; Zeleny, 1981; Swimme & Berry, 1992; Mingers, 1995; Hayles, 1999; Thompson, 2007; Rudrauf, Lutz, Cosmelli, Lachaux, & Le Van Quyen, 2003; Teubner, 1984; Geyer & van der Zouwen, 2001). In addition, despite the fact that some in mainstream science may view their ideas as marginal or wrong, both Maturana and Varela distinguished themselves as important, legitimate biologists through well-known laboratory work that served as the foundation for their theoretical ideas (Maturana, 1958; Lettvin, Maturana, McCulloch, & Pitts, 1968; Maturana, Uribe, & Frenk, 1968; Maturana, 1969; Varela, 1979; Rudrauf et al., 2003). Beyond the details of Maturana and Varela's particular views on the nature of biology, cognition, and knowledge, their work is important because it challenges one to examine fundamental assumptions about the nature of reality and to consider the ethical implications of being human and how we bring forth worlds with each other. Media and communications technologies play an important role in the bringing forth of worlds in today's global village as humanity stands on the precipice of unprecedented possible catastrophes. Ethical approaches to biology that help enhance our natural abilities for empathy and love coupled with the intelligent use of media and communications technology can serve as potent remedies to the many destructive tendencies that characterize our postmodern dominator culture, which clings to outmoded views about the nature of power relations among humans, humans' relationship to the natural world, and the ultimate nature of reality.

Maturana and Varela's approach is a unique synthesis of cutting-edge neurobiology, philosophy, and cognitive science that has implications for our understanding of human consciousness and the possibility of understanding ethics in a new way that could be beneficial to the survival and further evolution of the human species. From my perspective, these are also concerns of media ecology. By giving an overview of Maturana and Varela's thought, I hope to create a link that gives media ecology more depth by integrating a bio-communicative and world-enacting perspective based on a *comprehensive* view of cognition, the brain, and consciousness that transcends and includes (Wilber, 1996) current reductionist-only models of brain, mind, consciousness, and culture. I use the term comprehensive to denote the inclusion of both reductionist and holistic approaches for an integral view of cognition and consciousness. Varela (1999a) argues that reductionist and holistic views of systems should be complementary.

> There is a strong current in contemporary culture advocating 'holistic' views as some sort of cure-all. . . . Reductionism implies attention to a lower level while holistic implies attention to higher level. These are intertwined in any satisfactory description: and each entails some loss relative to our cognitive preferences, as well as some gain . . . there is no whole system without an interconnection of its parts and there is no whole system without an environment. (Varela in Rudrauf et al., 2003, p. 40)

A comprehensive view is necessary to continually move towards on-goingly refined perspectives that seek verisimilitude, "the attainment of increasingly closer approximations to the truth about physical process" (Polkinghorne, 1998, p.16).

Understanding Maturana and Varela's work from a media ecological perspective can situate their insights in a broader program for dealing with today's current searing matrix of communication technology and search for ways that autonomous biological entities and human societies can develop new evolutionary trajectories that are life-loving (biophilic) and life-producing (vivogenic) instead of marching to world wide cataclysm and mass extinction.

Biology, Cognition, and Media Ecology

Media and communication technologies have been created by biologically based human beings over the course of thousands of years of human evolution. Greater understanding of the biology of consciousness is crucial for a deeper understanding of how media helps shape our minds and cultures. The field of cognitive science itself has evolved with the evolution of technology and media. Technology has been created from the ideas of cognitive science and these technologies have also provided tools for the further development of hypotheses, theories, and applications of research in the cognitive sciences. By far the most important technology that emerged from the early days of cognitive science was the digital computer.

In his brief history of cognitive science, Francisco Varela (1992) defines the field as a combination of neuroscience, artificial intelligence, cognitive psychology, linguistics, and epistemology. He identifies four phases in the development of cognitive science beginning with its foundational years from 1943-1953 when the field was called cybernetics. During this time luminaries such as Norbert Wiener, John von Neumann, Alan Turing, Claude Shannon, Warren McCulloch, Heinz von Foerster, Gregory Bateson, and others made fundamental contributions that have had far reaching impacts. Varela (1992) summarizes what he thinks are five of the most important results of early work in cybernetics:

> • the use of mathematical logic to understand the operation of the nervous system;
> • the invention of information processing machines (as digital computers), thus laying the basis for artificial intelligence;
> • the establishment of the metadiscipline of system theory, which has had an imprint in many branches of science, such as engineering (systems analysis, control theory), biology (regulatory physiology, ecology), social sciences (family therapy, structural anthropology, management, urban studies), and economics (game theory);
> • information theory as a statistical theory of signal and communication channels;
> • the first examples of self-organizing systems (p. 237)

Much of this work was discussed, developed, and documented in a famous series of meetings called the Macy conferences that took place between 1943-1953 (von Foerster, 1955). As Varela (1992) notes, the advancements in the field,

> were all produced by intense exchange among people of widely different backgrounds: a uniquely successful interdisciplinary effort. . . . [However] by 1953, in contrast to their initial vitality and unity, the main actors of the cybernetics phase were distanced from each other and many died shortly thereafter. The idea of mind as logical calculation was to be continued. (p. 237-238)

Before continuing with Varela's history of cognitive science, it is important to acknowledge that each of the components that make up cognitive science has had its own unique history as a developing field of academic inquiry. It is beyond the scope of this paper to detail each of those histories, but it should be noted that of the various fields that comprise cognitive science, arguably, the most important scientific developments have taken place in neurobiology, which co-evolved along with the critical breakthroughs in molecular biology that began in the early 20th century and can be seen as having reached a high point with the first draft of the map of the human genome produced by the Human Genome Project and its various collaborators.

Nobel laureate Eric Kandel (2006) provides a unique and readable history of the development of neurobiology and many of the breakthroughs in knowledge about the brain and its bio-chemistry through the use of the reductionist (meant descriptively, not pejoratively in this context) tools developed in the field of molecular biology. The reductionist approach in science has yielded phenomenal results in that the knowledge that has been applied from this approach has produced powerful technologies such as pharmaceuticals, recombinant DNA, and sophisticated brain scan machines such as fMRI that have allowed humans unprecedented abilities to manipulate the physical and biological world (many more examples could be given). Thompson (2007) defines reductionism from two points of view, “Epistemological reductionism states that the best understanding of a system is to be found at the level of the structure, behavior, and laws of its component parts and their relations; ontological reductionism states that the relations between the parts of the system are all determined without remainder by the intrinsic properties of the most basic parts” (p. 417). This kind of scientific reductionism has its roots in the Newtonian/Cartesian cosmology that has come to define the modern age and which sees all of reality, including biological life, as a vast machine where objective scientific facts that are measurable and subject to precise mathematical formalization define the true nature of physical reality, independent of first person subjective experience.

There have been many undeniable insights and technical advancements that have allowed humans an unprecedented ability to shape the physical world around us; however, the standard reductionist approach has also brought many unexpected side-effects that have been deleterious to the biosphere and the human psyche (e.g., nuclear weapons, global warming, habitat and species destruction, existential social crises). Although scientific reductionism is necessary and useful in certain areas of study, for example, the development of a cancer drug or the launch of a space shuttle, reductionism nonetheless faces epistemological limits when confronted with problems of complex systems, ecosystems, human social realities, and the mystery of consciousness. John Searle (2009), an eminent philosopher of cognitive science, said in a recent keynote address that, despite profound advances in understanding the mechanisms of the brain, “We [still] do not know how the brain creates consciousness” (n.p.). The reductionist method of analyzing parts of systems without fully considering the immensely complex interconnections between various levels of phenomena, which include the irreducible complexities of human self-reflexive consciousness, results in an occluded view of the nature of knowledge and how it is constituted and experienced both through the material functioning of the brain and through individual human interaction with human societies and Gaian ecosystems.

It is precisely these deficiencies of the purely reductionist approach to cognitive science that Maturana and Varela have spent their careers trying to address (Maturana, 1969, 1988, 2007; Varela, Maturana, & Uribe, 1974; Maturana & Varela, 1980, 1992; Maturana & Poerksen, 2004; Varela 1979, 1996, 1999a; Varela, Thompson, & Rosch, 1993; Thompson, 2004, 2007; Rudrauf et al., 2003). During the first developmental phase of cognitive science (i.e., cybernetics) that Varela describes above, Humberto Maturana was completing his schooling and developing into a respected neurobiologist. After studying medicine and biology at the University of Chile, Maturana received a Rockefeller Foundation scholarship to study anatomy and neurophysiology at University College London where he worked with the eminent neuroanatomist, J. Z. Young. Soon after, he earned his Ph.D. in biology from Harvard in 1958 based on his electron microscope study of the frog brain.

Around the time that Maturana completed his Ph.D., Varela (1992) argues that the second phase of the development of cognitive science took place, which he terms, *cognitivism* (also sometimes called computationalism or symbolic processing). "The central intuition [of cognitivism] is that intelligence (including human intelligence) so resembles a computer in its essential characteristics that cognition can be *defined* as computations of symbolic representations" (p. 238, emphasis in original). The human brain is considered to be a massive information processing machine that manipulates, "symbols that represent features of the world or represent the world as being a certain way" (Varela, Thompson, & Rosch, 1993, p. 8). This school of thought became dominant in the 1960s and 1970s, especially in the field of artificial intelligence. Varela (1992) identifies two main critiques of this position,

> The first is that symbolic information processing is based on *sequential* rules, applied one at a time. This famous von Neumann bottleneck is a dramatic limitation when the task at hand requires large numbers of sequential operations. . . . The second important limitation is that symbolic processing is *localized*: the loss of any part of the symbols or rules of the system implies serious malfunction. (p. 243, emphasis in original)

The observations of neurobiologists contradicted both of these points. It was known that ordinary visual tasks in many types of animals "are done faster than is physically possible when simulated in a sequential manner" (Varela, 1992, p. 243) and that that local damage to the brain can be compensated for by parts of the brain that are still healthy (Doidge, 2007; Immordino-Yang, 2007a).

As a response to these problems, a new approach in cognitive science developed that Varela, Thompson and Rosch (1993) call *emergence* or *connectionism*.

> This name is derived from the idea that many cognitive tasks (such as vision and memory) seem to be handled best by systems made up of many simple components, which, when connected by appropriate rules, give rise to global behavior corresponding to the desired task. . . . Connectionist models generally trade localized, symbolic processing for distributed operations (ones that extend over an entire network of components) and so result in the emergence of global properties resilient to local malfunction. For connectionists a representation consists in the correspondence between such an emergent global state and properties of the world; it is not a function of particular symbols. (p. 8)

Ideas related to emergence and connectionism can be seen in other fields such as mathematics (dynamical systems theory), chemistry (dissipative structures) and systems science (Abraham & Shaw, 1985/1992; Prigogine & Stengers, 1984; von Bertalanffy, 1968; Laszlo, 1972). The emergence perspective emphasizes the network quality of systems and the spontaneous emergence of global patterns.

> In this approach each component operates only in its *local* environment, but because of the network quality of the entire system, there is global cooperation which *emerges* spontaneously, when the states of all participating components reach a

> mutually satisfactory state, without the need for a central processing unit to guide the entire operation. (Varela, 1992, p. 243-244, emphasis in original)

Varela acknowledges that the connectionist perspective is an improvement upon cognitivism and that there have been important studies that show various brain activities have emergent properties (Freeman, 1987). Nonetheless, Varela finds that connectionism does not fully account for a variety of other biological and epistemological problems. The primary issue for Varela (1992) is that connectionism, like cognitivism, still postulates that cognition is

> a successful representation of an external world which is pre-given, usually as a problem solving situation. However, our knowledge activity in everyday life reveals that this view of cognition is too incomplete. Precisely the greatest ability of all living cognition is, within broad limits, to *pose* the relevant issues to be addressed at each moment of our life. They are not pre-given, but *enacted* or *brought forth* from a background, and what counts as relevant is what our common sense sanctions as such, always in a contextual way . . . . If the world we live in is brought forth rather than pre-given, the notion of representation cannot have a central role any longer. (p. 250-251, emphasis in original)

Varela's dissatisfaction with what he sees as the limits of connectionism led him to develop his own approach that he calls *enactive cognitive science*.

> Enactive cognitive science is an approach to the study of mind that seeks to explain how the structures and mechanisms of autonomous cognitive systems can arise and participate in the generation and maintenance of viable perceiver-dependent worlds—rather than more conventional cognitivist efforts, such as the attempt to explain cognition in terms of the 'recovery' of (pre-given, timeless) features of The (objectively-existing and accessible) World. (McGee, 2005, p. 19)

Varela's enactive cognitive science emerged from the theory of autopoiesis that he developed with Maturana. His enactive cognitive science is an attempt to extend some of the original insights and epistemological implications of autopoiesis in a much broader way to include current cutting edge neuroscience laboratory work (that he was conducting at major research institutes in France such as CNRS, Centre National de Recherche Scientifique), a deep exploration of how phenomenological insights from thinkers such as Husserl, Heidegger, and Merleau-Ponty could contribute to how cognitive scientists deal with the issue of first person subjective experience when studying the brain, mind, and consciousness and an on-going reflection on his own personal consciousness that was deeply influenced by his study and practice of Buddhism (Varela, Thompson, & Rosch, 1993; Varela, 1996, 1999a; Hayward & Varela, 1992). Before considering Varela's enactive approach further, it is useful to trace the origins of his ideas in the development of the theory of autopoiesis.

Autopoiesis: The Ontogeny of an Idea

Varela's conception of enactive cognitive science is based, in part, on his years of work with Maturana and their development of autopoiesis theory (Varela, Maturana, & Uribe, 1974; Maturana & Varela, 1980, 1992). The word autopoiesis means self-producing or self-making and is used by Maturana and Varela to refer the "organization of the living" and to the basic definition of what characterizes a biological entity as being "alive" (Maturana & Varela, 1980).

> The most striking feature of an autopoieitic system is that it pulls itself up by its own bootstraps and becomes distinct from its environment through its own dynamics, in such a way that both things are inseparable. . . . By realizing what characterizes living beings in their autopoietic organization, we can unify a whole lot of empirical data about their biochemistry and cellular functioning. The concept of autopoiesis, therefore, does not contradict these data. Rather, it is supported by them; it explicitly proposes that such data be interpreted from a specific point of view which stresses that living beings are *autonomous* unities. (Maturana & Varela, 1992, p. 47, emphasis in original)

Maturana and Varela's theory of autopoiesis demonstrates how biological entities, through the organization of their components, self-produce the structures that define them as living beings and how they interact with their environment through, what they call, *structural coupling*. "Structural coupling . . . is a history of recurrent interactions leading to the structural congruence between two (or more) systems" (1992, p. 75). The structural coupling between systems affects the ontogeny of biological entities but the effects of these interactions are constrained by the biological structure of the autopoietic entity.

> Ontogeny is the history of structural changes in a particular living being. In this history each living being begins with an initial structure. The structure conditions the course of its interactions and restricts the structural changes that the interactions may trigger in it. (p. 95)

In organisms with a nervous system, it is the nervous system that acts as the link between the organism and its environment. Maturana and Varela argue that one of the most important characteristics of a nervous system is its operational closure (Maturana, 1975; Varela, Maturana, & Uribe, 1974; Maturana & Varela, 1980, 1992; Varela, 1979). Operational closure means that the nervous system maintains its organization, structure and integrity in the face of perturbations from the environment.

> The nervous system's organization is a network of active components in which every change of relations of activity leads to further changes of relations of activity. Some of these relationships remain invariant through continuous perturbation both due to the nervous system's own dynamics and due to the interactions of the organism it integrates. In other words, the nervous system functions as a closed network of

> changes in relations of activity between its components. (Maturana & Varela, 1992, p. 164)

This does not mean that the nervous system does not have plasticity or that it is not affected by its interaction with the environment. The operational closure of the nervous system preserves the organization of the components that comprise it and allows it to remain intact while it on-goingly interacts with the environment. If it did not maintain this organization and structure, then it would cease to exist as an autopoietic entity that is alive.

Maturana coined the term autopoiesis around 1970. The empirical data that prompted Maturana's first conceptions of the process of autopoiesis were rooted in early laboratory work. One of his first deep explorations of neurophysiology, which set the stage for his eventual shift in epistemological perspective, began with his 1958 Ph.D. dissertation on the neurophysiology of perception in the frog (Maturana, 1958). In a famous paper entitled "What the Frog's Eye Tells the Frog's Brain" (Lettvin, Maturana, & McCulloch, 1959/1968), Maturana and his senior co-authors (Warren McCulloch, Walter Pitts, and Jerry Lettvin, all prominent members of the Macy conferences),

> demonstrated, with great elegance, that the frog's visual system does not so much *represent* reality as *construct* it. What's true for frogs must also hold for humans, for there's no reason to believe that the human neural system is uniquely constructed to show the world as it "really" is. (Hayles, 1999, p.,131, emphasis in original)

This research set Maturana on a path that lead him to question the realist assumption that there is a pre-given objective world that is perceived by the brain as representations of objectively existing physical stimuli that are not dependent on the structure of the perceiving apparatus of the observer. In the 1960s, Maturana continued his laboratory research by studying color vision in birds and primates (Maturana, Uribe, & Frenk, 1968; Maturana, 1969). This research confirmed his previous findings from the frog study.

> He and his coauthors . . . found they could not map the visible world of color onto the activity of the nervous system. There was no one-to-one correlation between perception and the world. They could, however, correlate activity in an animal's retina with its *experience* of color. If we think of sense receptors as constituting a boundary between outside and inside, this implies that organizationally, the retina matches up with the inside, not the outside. From this and other studies, Maturana concluded that perception is not fundamentally representational. He argued that to speak of an objectively existing world is misleading, for the very idea of a world implies a realm that preexists its construction by an observer. Certainly there is something "out there," which for lack of a better term we can call "reality." But it comes into existence for us, and for all living creatures, *only through interactive processes determined solely by the organism's own organization.* (Hayles, 1999, p. 136-137, emphasis in original)

As he extrapolated his findings on the neurophysiology of various animals to how the human brain and nervous system work, he became convinced that any account of cognition must include the fundamental insight that, as observers (i.e., human beings with self-reflexive consciousness), we must be clear that, the world we perceive is primarily a result of the structure of our brain and nervous system and only secondarily the result of our structural coupling with other organisms and our environment. The results from these studies prompted Maturana to split from realist epistemology and the mainstream of reductionist biology. He argued that, as humans with brain based language and consciousness, we do not actually experience an absolutely objective world that is accurately re-presented to us faithfully through our cognition, but that we bring forth observer-dependent worlds with other autopoietic unities and our physical environment through, "a structural dance in the choreography of co-existence" (Maturana & Varela, 1992, p. 248). From these early realizations, Maturana set off to develop a definition of what constitutes life and cognition in light of his findings. His reflections led him to believe that the fundamental characteristic that defines something as living or not is the process of autopoiesis (self-making). In the mid-1960s Maturana met Varela when Varela was studying medicine and biology at the University of Chile. They became friends (first in a teacher/mentor role, then as colleagues) and began to develop the theory of autopoiesis in a series of publications both together and separately (Maturana, 1970; Varela, Maturana, & Uribe, 1974; Maturana & Varela, 1973, 1980, 1992).

Their explication of the theory of autopoiesis and its implications for biology, cognition, language, and human societies is written in dense language that requires special use of terms that Maturana and Varela define to describe their theory. This has been off-putting to some and to others evidence of the incoherence and ultimate falsity of their ideas. Despite this, Maturana and Varela's ideas have sparked a large body of literature (see bibliography) and on-going discussion about what is life, nature, society, cognition, communication, and consciousness.

Although Maturana and Varela are known together for the foundational literature they wrote concerning the theory of autopoiesis, they a have had their own separate careers that go far beyond their original theory. Maturana and Varela are both bona fide biologists who also took the rare road of actually subjecting their biological research and its implications to deep and on-going philosophical reflection; in effect mapping out a philosophical biology (Jonas, 2001). As biologists Maturana and Varela believe that, despite the fact that no totally objective material world can ever be known to us in any form that is not fundamentally mediated by the structure of our own nervous systems and brains, it is still possible to study the material and biological worlds in systematic and scientific ways. The trick is to be as clear as possible about the sets of assumptions that one holds as an individual so that one's research can be as rigorous as possible while attempting to achieve increasing verisimilitude and an openness to future revision that resists dogmatic certainty.

The epistemological shift that resulted from Maturana's early lab work led him to believe that the various definitions of life that were offered in the canon of biology were insufficient from his new perspective. While reflecting on his formative 10 years of lab research (1958-1968) he began to formulate what he thought were essential conditions to designate something as a living organism. He, like many biologists, started with the cell and saw that its process of self-production (autopoiesis) was the most fundamental characteristic that differentiated it from non-living molecules. Philosopher Evan Thompson (2007) provides a condensed definition of autopoiesis based on Varela's definition that he used toward the end of his life,

> For a system to be autopoietic, (i) the system must have a semipermeable boundary; (ii) the boundary must be produced by a network of reactions that takes place within the boundary; and (iii) the network of reactions must include reactions that regenerate the components of the system. (p. 101)

From approximately 1970-1992 Maturana and Varela meticulously elaborated their theory of autopoiesis in several papers and two full length books, one called *Autopoiesis and Cognition: The Realization of the Living* (1980) and a more accessible work called *The Tree of Knowledge: The Biological Roots of Human Understanding (*1992). In addition to defining autopoiesis, starting with cells and working up to animals, including humans, they wrote extensively about the implications of this foundational view to higher order concerns regarding human biological autonomy, cognition, social coordination, ethics, language and the evolution of societies and consciousness. William Irwin Thompson (1991) has referred to Maturana and Varela's corpus of work regarding these topics as the "Santiago School of Cognition." Others such as Fritjof Capra (1997) use that term as well, though outside of these two thinkers, as far as I know, the term has not been widely adopted. I use the term here as short-hand for the ideas that Maturana and Varela developed together starting with the theory of autopoiesis through the development of their ideas about cognition, structural coupling, language, ethics, societies, and the biology of love. A full accounting of all of their ideas together, and subsequently as they each worked separately, is beyond the scope of this paper but hopefully this short survey will spur further interest in reading their work. Following is a brief introduction to some other salient ideas that form the Santiago School.

Ethics, Language, and the Santiago School of Cognition

Although the Santiago School has always been somewhat marginal in the mainstream academic world, the literature surrounding their ideas is voluminous and some scholars and scientists still view their work as important (Thompson, 2007; Rudrauf et al., 2003).

Maturana and Varela's theory of autopoiesis leads to the conclusion that biological entities possess a fundamental biological autonomy as individual organisms distinct from their environment. Clearly, the environment in which a biologically autonomous entity is constituted will co-determine whatever world is brought forth. In the case of human beings, we try to bridge what neuroscientist Walter J. Freeman (2000) calls "solipsistic isolation" through language. One of the main criticisms of Maturana and Varela's perspective is that it is solipsistic. In their writing they argue why it is not. I will not try to elaborate on the details here. Regardless of this point, Maturana and Varela believe that language is crucial in constituting the worlds we bring forth with others and that since we are social animals, who can co-create worlds through language, all human living as constituted through language and the coordination of our social actions implies ethical considerations. Further, they argue that the development of language and increasingly complex coordination of social actions in the early history of humanity constituted a biology of love facilitated by the need for family members to take care of each other. They believe that human's inheritance of a biology of love should be nurtured and that language and the biology of love can help people bring forth better worlds together. The human biological capacity for love allows individuals to co-operate and to create a shared cognitive domain that brigdes solipsistic isolation.

> Biology . . . shows us that we can expand our cognitive domain. This arises through a novel experience brought forth through reasoning, through the encounter with a stranger, or, more directly, through an expression of a biological interpersonal congruence that lets us see the other person and open up for him room for existence beside us. This act is called love, or, if we prefer a milder expression, the acceptance of the other person beside us in our daily living. This is the biological foundation of social phenomena: without love, without acceptance of others living beside us there is no social process and, therefore, no humanness. Anything that undermines the acceptance of others, from competency to the possession of truth and on to ideologic certainty, undermines the social process because it undermines the biologic process that generates it. (Maturana & Varela, 1992, p. 246)

This quote from *The Tree of Knowledge* is one of the concluding thoughts after Maturana and Varela outline the tenets of the Santiago School. In later work (Maturana & Poerksen, 2004) Maturana comes back to the idea of the biology of love but not in a rigorous way. More work in this area could be useful, and it seems to be one of the main concerns that Maturana still thinks about. Concurrently and after Varela's collaboration with Maturana, Varela took the original ideas and worked them into his own personal research interests in laboratory neuroscience, philosophy, and Buddhism. Towards the end of his life he developed *the enactive* approach to cognitive science that was briefly described earlier in the paper. Following on his enactive approach to cognition he became interested in developing a field of study that he dubbed, "neurophenomenology" (Varela, 1996). "Neurophenomenology is grounded on a pragmatic will to progressively and systematically 'reduce the distance between subjective and objective . . . a way of narrowing the gap between the mental and the physical'" (Varela, 1997b in Rudrauf, et al., 2003). Varela's interest in Buddhism gives his work a unique perspective. Although I do not understand all of his research, his deeply humanistic and ethical approach to science, society, and consciousness keeps me interested in further study of his ideas.

Media Ecology and the Santiago School of Cognition

An important question is how do autonomous biological entities interact with their environments and how are they changed through their structural coupling with other systems? Structural coupling and the ontogenetic development of autonomous biological entities, like human beings, takes place through communication between an individual entity, other biological entities, and the physical environment. In the case of humans, the interactions taking place between an individual and other individuals and the overall environment are immensely complex. Since a large part of human communication takes place through human created communication technologies and media, it is important to try to understand how all of this communication can affect human consciousness and how different configurations of communication technologies result in different outcomes in consciousness in different individual humans and in turn how this informs social and cultural formations and evolution.

Media ecology attempts to study some of these questions from a comprehensive multi-disciplinary perspective, with the aim of providing insight into how media can damage or enhance individuals and societies and how various media ecologies may improve or diminish the prospect of human survival (Postman, 1970). Maturana and Varela's approach to how human consciousness is constituted from a biological perspective can help inform the study of media ecology by providing a complex naturalistic approach that takes into account the realities of the biological world and the role of the brain in co-creating our perceptions of reality. Media ecology can offer a way for Maturana and Varela's work to be considered in a broader context and can provide greater emphasis on how media shape our perceptions and societies. Although both Maturana and Varela do not believe that their theory of autopoiesis should be extrapolated to explain social formations (for a critique of Luhmann & Jantsch's attempts to do so see Maturana & Poerksen, 2004; for Varela's objection see Rudrauf et al., 2003), other parts of their work that follow from the theory of autopoiesis, such as Varela's enactive approach to cognitive science (Varela, Thompson, & Rosch, 1993; Thompson, 2007), and Maturana's concern with language, ethics and the biology of love (Maturana, 1978, 1988; Maturana & Poerksen, 2004) could clearly both contribute to and benefit from a media ecology perspective.

Media ecology's unique interdisciplinary and largely humanistic approach meshes nicely with the Santiago School perspective. It is not necessary to buy into every claim made by the set of ideas that emerge from Maturana and Varela's work, but their unique and deeply thought out perspective has many potentially useful lessons for how to more accurately understand our biological being and our subjectivity. Their ideas are useful, also, because they stimulate important questions about the nature of reality and how, as self-reflexive autopoietic unities (i.e., human beings) we can best comport ourselves in light of the natural facts of our existence and the profound mystery of consciousness in which we live out and reflect upon our lives. Insights from the perspective of the Santiago School are sometimes obscured by the complex, circular, and, at times, recondite language in which the core ideas are articulated. Critical tools from the discipline of media ecology could contribute to a more sophisticated way for the Santiago School to grapple with how media and communications technology impact human subjectivity while also helping develop more accessible ways to discuss the complex ideas that Maturana and Varela write about. Although Maturana and Varela shy away from some of their ideas, particularly autopoiesis, being applied in the social sciences and other fields, the work and ideas that follow from their original insight are relevant to many issues facing humanity today, especially how ethics and the biology of consciousness might work in tandem to provide possible viable solutions, or at least melioristic attempts at solutions, to the massive crises humanity now faces.

Media ecology is a lens that can enhance how we understand the link between our biological history and our cultural history. The Santiago School provides interesting tools to help us better understand who we are as biological and social animals. Cultural historian W. I. Thompson (1991), who was a close friend and colleague of Varela's, believes that cultural history, which incorporates perspectives such as the Santiago School, is critical to humanity's future survival and the establishment of a new planetary culture.

> We shall have to immerse ourselves in cultural history, and this means not simply gathering statistics in samples, but understanding the heart of the culture in its language, myth, religion, and art. As we begin to appreciate the complex membrane dynamics of cultural ecologies, we shall begin to move from the concept of the state as a container or piece of turf to the idea of the noetic polity. This shift in focus requires an act of imagination more than research and data-gathering; it involves movement away from regarding post industrial society as a collection of atomistic individuals competing to insert dollars in the bank and genes into females and articles in academic journals to a vision of symbiotic process in which groups constellate cognitive domains that encourage us to wonder about the 'pattern that connects' the bank to the ecology, the university to the universe. (Thompson, 1991, p. 256-257)

Both media ecology and the Santiago School can help develop cognitive domains where new perspectives on humanity's problems can be explored, debated and deployed as remedies for our wounded world.

References

Abraham, R., & Shaw, C. (1992). *Dynamics: The geometry of behavior* (2nd ed.). Redwood City, CA: Addison-Wesley, Advanced Book Program. (Original work published 1985.)

Capra, F. (1997). *The web of life: A new scientific understanding of living systems.* New York: Anchor.

Doige, N. (2007). *The brain that changes itself: Stories of personal triumph from the frontiers of brain science*. New York: Penguin.

Dougall, C. (2001). The autopoisesis of social systems: An Aristotelian interpretation. In F. Geyer & J. van der Zouwen (Eds.), *Sociocybernetics: Complexity, autopoiesis, and observation of social systems* (pp. 141-158). Westport, CT: Greenwood Press.

Freeman, W. J. (1987). Simulation of chaotic EEG patterns with a dynamic model of the olfactory system. *Biological Cybernetics, 56*, 139-150.

Freeman, W. J. (2000). *How brains make up their minds*. New York: Columbia University Press.

Geyer, F,. & van der Zouwen, J. (2001). Introduction to main themes in sociocybernetics. In F. Geyer & J. van der Zouwen (Eds.). *Sociocybernetics: Complexity, autopoiesis, and observation of social systems* (pp. 1-17). Westport, CT: Greenwood Press.

Hayles, N. K. (1999). *How we became posthuman: Virtual bodies in cybernetics, literature, and informatics*. Chicago: University of Chicago Press.

Hayward, J. & Varela, F. J. (1992). *Gentle bridges: Conversations with the Dalai Lama on the sciences of mind.* Boston: Shambhala.

in t' Veld, R.J. (1991). Autopoiesis, configuration, and steering: Impossibility theorem or dynamic steering theory. In R. J. in t'Veld, L. Schaap, C. Termeer, & M. van Twist (Eds.), *Autopoiesis and configuration theory: New approaches to societal steering* (pp. i-xxi). Boston: Kluwer Academic.

in t'Veld, R. J., Schaap, L., Termeer, C., & van Twist, M. (Eds.). *Autopoiesis and configuration theory: New approaches to societal steering*. Boston: Kluwer Academic.

Jantsch, E. (1980). *The self organizing universe: Scientific and human implications of the emerging paradigm of evolution.* New York: Pergamon Press.

Jonas, H., (1985). *The Imperative of Responsibility: In search of an ethics for the technological age.* Chicago: University of Chicago Press.

Jonas, H., (2001). *The Phenomenon of Life: Toward a philosophical biology.* Forward by L. Vogel. Chicago: Northwestern Univ. Press. (Original work published 1966).

Kandel, E. R. (2006). *In search of memory: The emergence of a new science of mind.* New York: Norton.

Laszlo, E. (1972). *Introduction to systems philosophy: Toward a new paradigm of contemporary thought*. New York: Gordon and Breach.

Lettvin, J. Y., Maturana, H. R., McCulloch, W. S., & Pitts, W. H. (1968). What the frog's eye tells the frog's brain. In W. Corning & M. Balaban (Eds.), *The mind: Biological approaches to its function* (pp. 233-258). New York: Wiley. (Original work published 1959.)

Lewis, T., Amini, F., & Lannon, R. (2000). *A general theory of love*. New York: Random House.

Luhman, N. (1995). *Social systems*. Stanford: Stanford University Press.

Margulis, L., & Sagan, D. (Eds.). (1997). *Slanted truths: Essays on symbiosis, Gaia and evolution*. New York: Copernicus.

Maturana, H. (1958). *The fine structure of the optic nerve and tectum of anurans: An electron microscope study*. Unpublished Ph.D. dissertation, Harvard University.

Maturana, H. (1969). The neurophysiology of cognition. In P. Garvin (Ed.), *Cognition: A multiple view* (pp. 3-23). New York: Spartan Books.

Maturana, H. (1970). *Biology of cognition*. BCL Report 9.0. Biological Computer Laboratory. Department of Electrical Engineering, University of Illinois.

Maturana, H. (1975). The organization of the living: A theory of living organization. *International Journal of Man-Machine Studies, 7*, 313-332.

Maturana, H. (1978). Biology of language: The epistemology of reality. In G. Miller & E. Lenneberg (Eds.), *Psychology and biology of language and thought* (pp. 1-27). New York: Academic Press.

Maturana, H. (1988). Reality: The search for objectivity or the quest for a compelling argument. *Irish Journal of Psychology, 9*(1), 25-82.

Maturana, H. (2007). The nature of the laws of nature. *Systems research and behavioral science, 17*(5), 459.

Maturana, H., & Poerksen, B. (2004). *From being to doing: The origins of the biology of cognition.* Heidelberg: Carl-Auer.

Maturana, H. and Varela, F. (1973). *De máquinas y seres vivos; una teoría sobre la organización biológia*. Santiago, Chile: Editorial Universitaria.

Maturana, H., & Varela. F. (1980). *Autopoiesis and cognition: The realization of the living*. Boston: Reidel.

Maturana, H., & Varela, F. (1992). *The tree of knowledge: The biological roots of human understanding.* Boston: Shambhala.

Maturana, H., Uribe, G., & Frenk, S. (1968). A biological theory of relativistic color coding in the primate retina. *Archivos de biologica y medicina experimentales,* Suplemento No. 1. Santiago.

McGee, K. (2005). Enactive cognitive science part 1: Background and research themes. *Constructivist Foundations, 1*(1), 19-82.

Mingers, J. (1995). *Self-producing systems: Implications and applications of autopoiesis*. New York: Plenum.

Polkinghorne, J. (1998). *Science and theology: An introduction*. Minneapolis: Fortress Press.

Postman, N. (1970). The reformed English curriculum. In A.C. Eurich (Ed.), *High school 1980: The shape of the future in American secondary education*. New York: Pitman Publishing Corp. Retrieved 10 May 2009 from http://www.mediaecology.org/media_ecology/index.html#What%20is%20Media%20Ecology?%20%28Neil%20Postman%29.

Prigogine, I. & I. Stengers. (1984). *Order out of chaos: Man's new dialogue with nature*. New York: Bantam Books.

Rudrauf, D., Lutz, A., Cosmelli, D., Lachaux, J. P., & Le Van Quyen, M. (2003). From autopoiesis to neurophenomenolgy: Franscisco Varela's exploration of the biophysics of being. *Biol Res. 36*, 21-59.

Searle, J. (2007). *Freedom and neurobiology: Reflections on free will, language, and political power.* New York: Columbia University Press.

Searle, J. (2009). The current state of cognitive science. *California cognitive science association*. Keynote address. Berkeley: UC Berkeley.

Strate, L. (2006). *Echoes and reflections: On media ecology as a field of study.* New York: Hampton Press.

Swimme, B., & Berry, T. (1992). *The universe story: From the primordial flaring forth to the ecozoic era—a celebration of the unfolding of the cosmos.* San Francisco: Harper San Francisco.

Tuebner, G. (Ed.). (1988). *Autopoietic law: A new approach to law and society*. New York: W. de Gruyter.

Thompson, E. (2004). Life and mind: From autopoisesis to neurophenomenology. A tribute to Francisco Varela. *Phenomenology and the cognitive sciences, 3*, 381-398.

Thompson, E. (2007). *Mind in life: Biology, phenomenology, and the sciences of mind*. Cambridge, MA: Belknap/Harvard Univ. Press.

Thompson, W.I. (Ed.). (1991). *Gaia 2, emergence: The new science of becoming*. Hudson, N.Y.: Lindisfarne Press.

Varela, F. (1979). *Principles of biological autonomy.* Boston: Kluwer Academic.

Varela, F. (1992). Whence perceptual meaning? A cartography of current ideas. In F. Varela & J. P. Dupuy (Eds.), *Understanding origins: Contemporary views on the origins of life, mind and society* (pp. 235-263). Boston: Kluwer Academic.

Varela, F. (1996). Neurophenomenology: A methodological remedy for the hard problem. *Journal of consciousness studies, 3*, 330-350.

Varela, F. (1999a). *Ethical know-how: Action, wisdom, cognition*. Palo Alto: Stanford Univ. Press.

Varela, F. (1999b). Present-time consciousness. In F. J. Varela & J. Shear (Eds.), *The view from within: First-person approaches to the study of consciousness* (pp. 111-140). Bowling Green, OH: Imprint Academic.

Varela, F., Maturana H., & Uribe, G. (1974). Autopoiesis: The organization of living systems, its characterization, and a model. *Biosystems, 5*, 187-196.

Varela, F., Thompson, E., & Rosch, E. (1993). *The embodied mind: Cognitive science and human experience.* Cambridge, MA: MIT Press.

von Bertalanffy, L. (1968). *General system theory: Foundations, development, applications.* New York: George Braziller.

von Foerster, H. (Ed.). (1955). *Cybernetics: The Macy conferences 1946-1953*. New York: Josiah Macy Foundation.

Wilber, K. (1996). *A brief history of everything.* Boston: Shambhala.

Zeleny, M. (Ed.). (1981). *Autopoiesis: A theory of living organization*. New York: North Holland.