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Complex Human (Un)Adaptive Systems and Feedback: A Framework for Biological & Social Inquiry

Introduction

As the message about global climate change becomes more urgent, far more people are wondering how humankind should alter their behavior in response. After all, humans are able to adapt their individual and group behavior as a result of experience. Humankind is also a great representation of a complex adaptive system due to our extensive ability to communicate, cooperate, organize and reproduce. However, it has been very difficult to model biologically and socially.

Figure 1 represents a framework for the Complex Human Adaptive System (CHAS). The blue circle and inner circles represent spheres of influence in a hierarchical fashion. These spheres are not neatly divided, their boundaries diffuse. The CHAS can be thought of as a water balloon, with every water molecule, or system agent, linked to the other in the most direct and indirect avenue. Most importantly, a disturbance in any one sphere of influence will send ripple affects across all other spheres.

Human Stimulus and Response

Because this is an inquiry into how humanity functions homeostatically as a CAS, it is appropriate to illustrate how humanity responds to stimuli. These stimuli and their associated responses can be physiological, psychological, or a combination. As seen in Figure 1, sources for human stimulation exist far out of our solar system: astrophysical determinants and planetary impacts. However, human responses to stimuli are limited by the biosphere; we can not (yet?) affect the cosmos. Furthermore, human stimulus and behavior are a cycle involving the feedbacks of spheres of influence. The logic follows:

1. The aggregation of stimuli provides individuals and populations a perspective (or ethos or method) on which to base their behavior.
2. Human behavior can have a ripple affect across all spheres of influence
3. Changes in any sphere of influence therefore affects human stimuli and perspective
4. Human stimulation and behavior, therefore, is a cycle affected by a multitude of complex adaptive systems (economics, politics, ecosystems, the biosphere can be thought of as CAS).

At the very center of the CHAS is humanity, which is represented by distinct populations of communities. At the individual and group level, responses seem to be dominated by a stimulus of fear (apocalyptic psyche meme; lack of knowledge), tradition (culture & religion) and curiosity (quest for knowledge; science). Thus, the spheres most immediately influenced by human response will be daily life, or economics. The political

sphere typically serves as a regulatory platform within which economies function and social institutions express themselves. In totality, the *method of existence* includes all social spheres of influence, ie institutions of government, economics, religion, and other memes.

Humankind's method of existence is largely dominated by our relationship with our ecosystem, or natural resources. This relationship has been dramatically altered by technology and all other underlying spheres of influence. In short, the relationship between human capital and natural capital provides a sphere in which humans consume.

Mode of Consumption

Karl Marx attempts to define the combination of natural "productive forces" and the human social and technical relations as *mode of production* (Tucker, et al.). In short, humankind's production is some function of natural (biospheric) and human (physiological, psychological, institutional) capital. However, Marx is only illustrating half of the *cycle*. As organisms, humans must ***consume*** to produce! Therefore, our *mode of consumption* is also inseparable from natural and human capital. This distinction can have obvious implications for global environmental change: the human *consumption* of fossil fuels *produces* greenhouse gases.

Using Figure 1, it can be easily shown how changes in the biosphere should affect the noosphere, our mode of consumption and method of existence. For humans to be classified as complex adaptive systems, we must ***adapt***, or alter our behavior due to a change in stimuli. If humans are merely multi-agent system (MAS), then evolutionary biology would indicate that climactic variation will more easily weed us out, and "select" a more appropriate complex system (Lecture 6)[1]. Let's hope not! In essence, human resiliency to perturbations is defined by the human ability to adapt in a homeostatic fashion.

Case Study: Dendritic signalling and homeostatic adaptation

Homeostatic adaptation can be very difficult to illustrate on the global scale due to the shear complexity of agents and systems. However, Yu and Goda (2009) have demonstrated homeostatic adaptation on the level of a single neuron (Figure 2). In short, Yu and Goda manipulated the neuron's environment using blocking receptors to induce increased firing rates (synapse). They found that upon sustained blockade, firing rates returned to basal levels over a period of no more than 96 hours. Thus, Yu and Goda conclude that "these findings suggest that neurons have developed sophisticated mechanisms to enable neuronal firing to be maintained within a set range despite the activity perturbations" (Yu and Goda 2009).

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[1] The ecosystem is clearly the vehicle of selection, despite the fact that species and genes qualify as replicators. (Swensen)

This neurobiological study illustrates an important point. The homeostatic regulatory systems of the neuron, given stimulus, responds by altering the neuron's behavior over time. Thus, the new behavior is the reflection of a reorganization of internal components and feedback systems (although this shift in behavior undoubtedly must affect its environment as it is part of a cycle). What did the neuron ***not*** do? It is important to note that the neuron responded with an internal adjustment; it did not manipulate the environment which created the perturbation to maintain an internal, static, and behavioral status-quo.

If we were to apply this revelation to the CHAS, we might assume that for humans to adequately respond to changing stimuli, we must first alter our internal spheres, or methods of existence. This behavioral adaptation begins with the individual, expands among communities and populations, influences collective decision making, and thus manifests globally to form a state of homeostasis. Such dramatic human responses are not only possible, but structure human history. For example, the American Revolution of the 1770s, the reunification of Germany in 1990, and the modern Syrian liberation all reveal the adaptive capacity of humanity in response to harmful stimuli.

For the neuron, it can't be explained exactly what catalyst sparks the adaptive response to its change in environment. However, for the human species it seems more obvious. Have we here set the stage for… the altruistic gene?![2]

[2] For example, a typical group selection model attempts to show how a gene for altruism can evolve by increasing the fitness of whole groups, despite being selected against within groups. For the model to work, there must be a process of natural selection at the group level (a population of groups, variation among groups, etc.) that counterbalances natural selection within groups. (Swensen p9113)

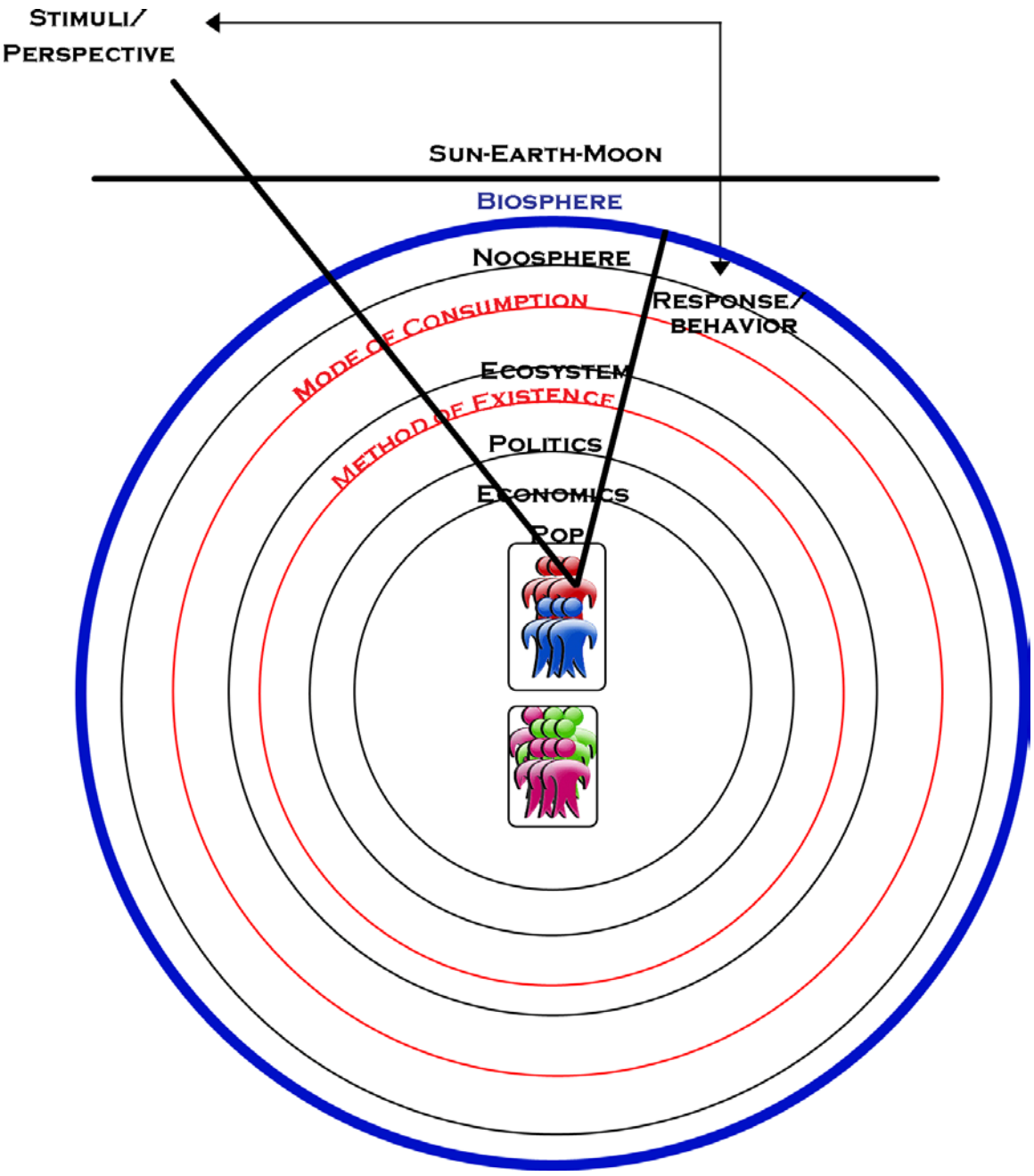

Figure 1 – An illustration of the Complex Human Adaptive System. Such a system includes the cycle of human stimulation and behavior as it resonates among hierarchical spheres of influence.

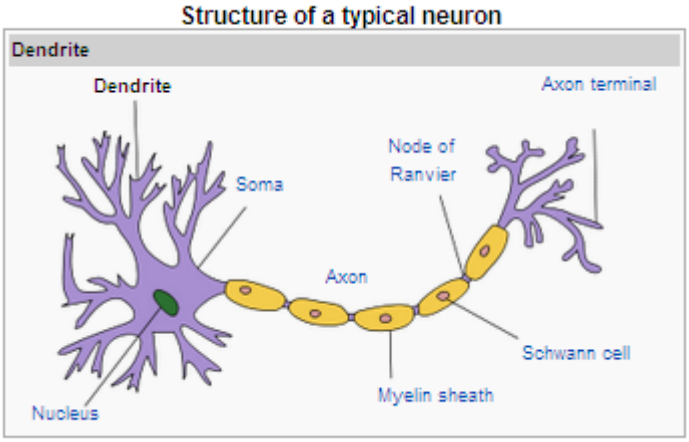

Figure 2 – Illustration of a neuron[3]

References

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Swenson, William; Wilson, David Sloan and Elias, Roberta, "Artificial ecosystem selection" PNAS, Volume 97, Number 16, Pages 9110-9114.

Yu, Lily MY and Goda, Yukiko, "Dendritic signaling and homeostatic adaptation" *Current Opinion in Neurobiology*, Volume 19, Issue 3, June 2009, Pages 327–335

[3] http://en.wikipedia.org/wiki/Dendrite - wikipedia image, don't shoot me.