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Author
Jordan, Jerome Scott

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Wild Systems Theory: Overcoming the Computational-Ecological Divide via Self-Sustaining Systems

J. Scott Jordan (jsjorda@ilstu.edu)
Department of Psychology, Illinois State University, Campus Box 4620
Normal, IL 61790-4620

Abstract

For years, there has been a tension between computationalist cognitive scientists who utilize the notion of representation and efficient-cause in their accounts of mind, and dynamical-systems oriented ecological psychologists who eschew representationalism and efficient-cause in favor of multi-scale, contingent interactions and embodiment. The present paper presents a recently-developed theory of embodiment, Wild Systems Theory (WST), that was developed to overcome this riff. WST conceptualizes organisms as multi-scale self-sustaining embodiments of the phylogenetic, cultural, social, and developmental contexts in which they emerged and in which they sustain themselves. Such self-sustaining embodiments of context are *naturally* and *necessarily* about the multi-scale contexts they embody. As a result, meaning (i.e., content) is constitutive of what they are. This approach to content overcomes the computationalist need for representation while simultaneously satisfying the ecological penchant for multi-scale contingent interactions.

Keywords: representation; phenomenology; embodiment; philosophy.

Wild Systems Theory

For years, there has been a tension between computationalist cognitive scientists who utilize the notion of representation and efficient-cause in their accounts of mind, and dynamical-systems oriented ecological psychologists who eschew representationalism and efficient-cause in favor of multi-scale, contingent interactions and embodiment. Wild Systems Theory (WST) is a new theory of embodiment that was developed to overcome this riff. My central thesis is that organisms (i.e., bodies) *are* meaning (and ultimately mind), precisely because they constitute embodiments of the external constraints (i.e., contexts) they have had to phylogenetically, as well as ontogenetically internalize in order to sustain themselves (Jordan, 1998). Within this framework, fins constitute an embodiment of the hydrodynamic properties of water, bones, an embodiment of the constraints that need to be overcome in order to propel a body through a gravity field, and teeth, an embodiment of the make-up of plants and what it takes to release the chemical energy they contain. In every case, these embodiments are *naturally* and *necessarily* "about" the environmental constraints they evolved to address. It is this necessary "aboutness" that I want to define as meaning and, ultimately *mind*.

But does this notion of internalized constraints really naturalize meaning and, ultimately mind? One could argue that the body of a submarine, the body of a car and the body of certain farm tools also constitute embodiments of water, gravity and plants, respectively. Do they really constitute *meaning*? Of course, I have to say yes, but I would also add that this is not the type of meaning that ultimately evolved into mind. To be sure, the designers of submarines, cars and farm tools constructed such bodies so that their internal structure reflected the external constraints within which they have to function. The difference between these bodies however, and biological bodies is the means by which they sustain themselves. Biological bodies do so by continuously taking in, transforming, and dissipating energy. Non-biological bodies do not. It is my position that it is this wild, interactive-internalization of local context (i.e., energy transformation) that afforded, and continues to afford biological systems the means by which their embodied meaning was and is capable of evolving into mind. This is because the work (i.e., energy transformation) that constitutes biological bodies is *self-sustaining*. That is, it produces products that feed back into and sustain the work. Kaufmann (1995) recognized this principle at the chemical level and refereed to it as *autocatalysis*. Specifically, an autocatalytic (i.e., self-sustaining) chemical system is one in which the work (energy transformations) taking place among molecules, produces its own catalyst. By producing its own catalyst, the work sustains itself, as well as the system as a whole. Kauffman conceptualizes such work as a self-sustaining metabolism and argues that the emergence of such systems constituted the emergence of living systems.

According to Wild Systems theory, such self-sustaining "work" constituted a type of meaning—what Jordan and Ghin (2006) refer to as *content*—that proved capable of evolving into mind. It constituted *meaning* because the work, as well as the global whole it sustained, was naturally and necessarily "about" the external constraints the system had to embody in order to sustain itself. It constituted *content* because it gave rise to (i.e., was *for*) the global whole (i.e., the body) it sustained, while the body (i.e., the sustained global whole) synergistically provided a sustained context in which the internal work could be *for* something (cf., Bickhard, 2001; Jordan & Ghin, 2006). And it proved capable of affording the evolution of mind because it constituted a potential fuel source (i.e. encapsulated energy). That is, the energy entailed in such a system could be captured by another system. But to be capable of doing so, the latter had to internalize (i.e., embody) all the constraints that needed to be addressed in order to capture the energy encapsulated in the former. Said another way, once plant energy was widely available, it provided a context in which a system could emerge that sustained itself on plant energy. From this perspective, herbivores can be seen as embodiments of the constraints that need to be internalized in order for a system to sustain itself on the energy encapsulated in plants, and carnivores, the constraints to be addressed to sustain a system on the energy encapsulated in herbivores. What we have here then, is a continuing recursion on a simple theme; specifically, *the fuel source dictates the consumer*. From this perspective, the world of nature is conceptualized as a self-organizing energy transformation hierarchy (Odum,1988; Vandervert, 1995) in which any newly emerging systems constitute embodiments of the constraints they have to address to sustain themselves within this transformation hierarchy.

According to WST, within the context of such a self-sustaining hierarchy, *mind* emerges when systems emerge that are capable of embodying (i.e., internalizing) *virtual* content. By virtual, I simply mean content that is "about" events that are non-existent in the present context. Take, for example, a lion chasing a gazelle. Lotka (1945) recognized that in order to capture the energy entailed in the gazelle, the lion must propel itself as a whole on an *anticipatory* pursuit curve. What makes the pursuit curve anticipatory is the fact the lion runs toward a location the gazelle does not yet occupy. In short, it propels itself toward the gazelle's *future*. The reason it can do so is because it has embodied (i.e., internalized) the constraint of having to capture a moving energy source. Specifically, certain structures in the lion's cerebellum have access to both the movement commands leaving motor cortex, and the immediate sensory consequences of the resultant movements. These cerebellar structures project back up to motor cortex and influence its activity. This is important, for it affords the lion the ability to embody (i.e., internalize), in the weights of its cerebral-cerebellar circuitry, patterns between motor commands and their resultant sensory effects. Thus, as the lion garners experience controlling its body in relation to moving prey, successful command-feedback patterns become embodied in the cerebral-cerebellar circuits. And given these cerebral-cerebellar loops influence motor cortex and function at a time scale of 10-20 milliseconds, versus the 120 millisecond time-scale between motor commands and sensory feedback, the system can basically control is propulsion on *virtual* feedback (Clark, 1997; Grush, 2004) and, as a result, propel itself toward internalized (i.e., embodied) *virtual* prey locations (i.e., where the prey will be in the next 200 or so milliseconds).

There are five important points to be made about such *virtual* content. First, it is not virtual in the sense it does not exist. To the contrary, it does exist. It is virtual in the sense it is about *future* body-prey states. Second, it is possible for the lion to embed (i.e., embody) such content within its brain because neural networks function according to the principle of self-sustaining work. Hebb (1949) recognized this aspect of neural work and refereed to it as the cell-assembly; the notion that neurons sustain themselves by becoming part of a neural network. Edelman (1989) also noted this principle in the developing brain, and referred to it as *Neuronal Darwinism*. In short, the work of being a neuron (i.e., producing action potentials and forming synapses with other neurons) sustains the neuron. Thus, patterns of neural activity sustain themselves, and factors that cause neural patterns to repeat (i.e., command-feedback patterns in cerebral-cerebellar loops and their relationship to prey patterns) become embedded (i.e., embodied) within these self-sustaining neural patterns.

Third, all of this embodied work is naturally and necessarily about the external (as well as internal) contexts (patterns) that have to addressed in order for the work to sustain itself; from the single neuron, to the neural circuit, to the neuro-muscular system, to the organism as a whole. Thus, there is no epistemic divide between internal and external states (including virtual states)—organisms are reciprocally nested eco-systems of self-sustaining work. They are a representation, at every level, of the phylogenetic, as well as ontogenetic constraints their species has had to overcome in order to sustain itself.

This leads to the fourth point. Virtual content emerged in self-sustaining systems precisely because of their need to capture energy that was on the move. The virtual content therefore, is necessarily about the *other*. That is, it is not just about the command-feedback patterns in the lion's brain, but rather, the relationship between command-feedback patterns and their relationship to prey patterns. The point I'm after here is that the virtual content is inherently *other-relative*. If we assume that the ability to chase gazelles phylogenetically emerged prior to the ability to have self-consciousness about chasing gazelles, it seems to be the case that *others* were in the brain before the *self* was. In short, the brain has never been alone. This claim is supported by the discovery of areas in the brain (i.e., mirror neurons) that are active both when one plans a goal related action, as well as when one observes another execute such an action (Rizzolatti, Fadiga Fogassi, & Gallese, 2002). This means that as others produce goal-directed actions, they simultaneously put my brain in a planning state for the same goal-related action. The discovery of such mechanisms indicates that resonance (i.e., doing what others are doing) constitutes the default value in human interaction. Kinsbourne (2002) agrees with this position and argues that infant imitation is actually uninhibited perception "on the fly". Only as the cortex develops inhibitory circuits, he argues, are we able to "not" resonate to the actions of others. He cites echopraxia as further evidence of this claim. Rizzolatti et al. agree with this notion of resonance, and distinguish between low- and high-level resonance. While the former refers to the ability of an organism's body movements to entrain similar movements in conspecifics (e.g., a school of fish moving together, or a flock of birds flying together), the latter refers to resonance at the level of goal related actions (e.g., a chimp watching another eat a peanut, or a person watching another dance). Collectively, these findings indicate that the *othe*r was embodied in the structure of the brain very early on, and has been there ever since.

And finally, the fifth point about virtual content is that it sets the stage for the emergence of phenomenal self-experience (Ghin, 2005; Metzinger, 2003). For since neural networks emerge and function according to the principle of self-sustaining work, the virtual content embedded in a brain is always available for "capture" by newly-emerging neural networks (Grush, 2004). The content of these new circuits will necessarily constitute an abstraction from the content embedded and sustained in the network it is tapping into.

As systems emerged that were capable of externalizing and sharing virtual content (i.e., communicate), the ability to "capture" such content required the system be able to distinguish its own, internally-generated virtual content from that entering the system from the outside. These are the constraints that I believe forced the emergence of "self" and "other" (Jordan, 2003c; Jordan & Knoblich, 2003; Knoblich & Jordan, 2003). In short, the self emerges as foreground amidst a background of virtual others, and it does so in order to sustain itself with those others in virtual contexts (i.e., within a world of ideas). The phenomenal self then garners its content (i.e., phenomenal properties) as do all self-sustaining systems; from the fact it is naturally and necessarily "about" the context (i.e., the externalized virtual content of others) it must embody in order to sustain itself.

The idea that the other has always been there, embodied within us, seems to render communication more an act of self-sustaining resonance among embodied others than an act of information exchange between lone cognizers. It does so because self-sustaining systems do not need to "perceive" their environment in order to be "about" it. Rather, they are naturally and necessarily about the contexts they have embodied, including the context of others. Environments therefore, including the world of others, modulate (versus 'cause') what self-sustaining systems are "about". Communication therefore, at least among self-sustaining embodiments, is an act of reciprocal modulation (i.e., resonance). And in order for such resonance to sustain itself, participants must generate work (e.g., eye-contact, gestures and head nods) to sustain the joint modulation. In short, communication itself is a self-sustaining process. Instead of constituting work among chemical systems embedded in a pre-biotic soup however, it constitutes work among embodied others embedded in a sea of virtual meaning.

Overcoming the Divide

Given its ability to satisfy the concerns of both computationalists and ecological psychologists without violating the assumptions of either, WST might be in a position to integrate the two theories. As regards computationalism, WST address the notion of representation by arguing that all aspects of an organism constitute representations, in that, all aspects of the organism constitute embodiments of context. In short, an organism represents all the scales of context that have had to be addressed for it to phylogenetically emerge and sustain itself. Representation, therefore, is not a property that distinguishes brains for other aspects of an organism. What distinguishes brains however, is the time-scale at which embodiment takes place. The emergence of a particular memory emerges and sustains itself at a much faster set of time scales than the time-scales by which individual neurons, neural nets, and entire brains emerge and sustain themselves. Regardless of this difference however, representation is there at every time-scale of self-sustaining work.

In addition to addressing representation in an ecologically-friendly way, WST also addresses computationalism's reliance on efficient cause as an explanation of content manipulation. Computationalism is led to efficient-cause by its assumption there exist specific levels in a cognitive architecture that are sufficiently isolated from other levels to enable them to 'bear' content. This assertion is proving increasingly difficult to defend as neuroscience provides more and more data indicating the immensely recursive, interconnected nature of neural organization. WST address this issue by conceptualizing neural dynamics in terms of multi-scale, contingent interactions. Given such embodiments are naturally and necessarily about the contexts they embody, WST encounters no need to pose sufficiently isolated 'vehicles' of content. Content is constitutive of what self-sustaining embodiments are. And conscious and cognition are not so much computational processes that take place in specific levels of a cognitive architecture, as they are emergent levels of self-sustaining work whose 'aboutness' cannot be reduced to any one level of work. Consciousness and cognition are irreducibly 'about' all such levels of work.

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