Wild agency: nested intentionalities in cognitive neuroscience and archaeology

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The present paper addresses the tensions between internalist and radical-interactionist approaches to cognitive neuroscience, and the conflicting conclusions these positions lead to as regards the issue of whether archaeological artefacts constitute ‘results’ or ‘components’ of cognition. Wild systems theory (WST) and the notion of wild agency are presented as a potential resolution. Specifically, WST conceptualizes organisms (i.e. wild agents) as open, multi-scale self-sustaining systems. It is thus able to address the causal properties of wild systems in a manner that is consistent with radical-interactionist concerns regarding multi-scale contingent interactions. Furthermore, by conceptualizing wild agents as self-sustaining embodiments of the persistent, multi-scale contexts that afforded their emergence and in which they sustain themselves, WST is able to address the semantic properties of wild agents in a way that acknowledges the internalist concerns regarding meaningful (i.e. semantic) internal states (i.e. *causal content*). In conclusion, WST agrees with radical interactionism and asserts that archaeological artefacts constitute components of cognition. In addition, given its ability to resolve tensions between the internalist and the radical interactionist approaches to cognition, WST is presented as potentially integrative for cognitive science in general.

Keywords: cognition; interactionism; internalism; self-sustaining systems; developmental systems

Removing the arrows of modernity from the archaeological perceptual field is not an easy task; it will involve a great deal of cognitive dissonance (Malafouris, 2003). Yet to tackle the complex intentionalities enacted through the materiality of the archaeological record, we need to move on and where necessary transgress the ontological tidiness of our modern taxonomies...

(Malafouris 2004, p. 54)

1. INTRODUCTION

What Malafouris seems to be after in this quotation is a rethinking of the relationship between cognitive science and archaeology, specifically as regards the manner in which we conceptualize cognition and the impact that conceptualization has on our interpretation of archaeological data. In modern taxonomies, cognition is conceptualized as an internal, centralized decision-making function that uses perceptual input in order to generate the appropriate behavioural output (Clark 1997, 2001; Jordan 2003a, 2004). Within the framework of such *internalism*, the archaeological record is conceptualized as constituting a ‘result’ of cognition.

Despite our long-standing commitment to internalism and the clear boundaries it implies between mind and world, many researchers in cognitive psychology (Glenberg 1997; Barsalou 1999; Zwaan 1999; Jordan 2000a,b; Wilson 2002), robotics (Brooks 1999;

Anderson 2003; Steels in press), philosophy (Clark 1997, 2000; van Gelder 1998; Juarrero 1999; O’Regan & Nöe 2001; Myin & O’Regan 2002; Van Orden & Holden 2002) and archaeology (Malafouris 2004) are working to develop approaches to cognition that are much more interactionist in nature. That is, they place greater emphasis on the fact that the brain is housed in a body that is embedded in a world, and then examine the extent to which the phenomenon of cognition can be ‘spread-out’ as it were, across these multiple scales of interaction. Clark (2001) for example, describes research in which it was found that expert bartenders remember drink orders better than novices because they *externally* code each order by selecting a particular type of glass for that order. According to Clark, the use of such *external codes*, what he refers to as *cognitive technology*, begs the issue of whether these material artefacts are constituents or products of cognition. The distinction is important. If they are products, internalism prevails, but if they are constituents, the ontological tidiness of internalism begins to clutter as the borders between mind and world become increasingly vague, and artefacts in the archaeological record find themselves potentially conceptualized as components of mental work.

Oyama (1985) offers a potential resolution of the tension between internalism and interactionism. Specifically, she argues that the mind–world dichotomy inherent in internalist approaches to cognition constitutes but a special case of a more general tendency in the natural sciences to explain large-scale phenomena such as phenotypes and behaviour in terms of smaller scale ‘agent-like’ structures such as genes and brains, respectively. What Oyama means by this is not that researchers believe genes have minds. Rather, what she

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is after is our tendency to conceptualize smaller scale structure as entailing ‘information’, ‘instructions’, ‘codes’ or ‘plans’ for larger scale phenomena.

Oyama rejects this view, what she refers to as the *cognitive-causal gene*, and proposes a radically interactionist alternative, what she refers to as developmental systems theory (DST), because she believes that structures at all levels of scale are ultimately constituted of multi-scale, interaction-driven dynamics. *All* aspects of development are therefore inherently context dependent, and the science of any developmental process, from the development of a phenotype to the development of a group or a society, must account for these multi-scale contingent contexts instead of glossing over them via phrases such as *ceteris paribus*, or the use of agent-like entities that are assumed to ‘pre-specify’ or ‘code for’ larger scale order. According to this view, organisms inherit, in addition to genes, the multi-scale contexts necessary for the emergence of a phenotype—what Oyama collectively refers to as a *developmental system* (e.g. the persistence of contexts entailing available food, clothing, shelter and other organisms).

At first glance, DST seems to resolve the tension between internalist and interactionist approaches to cognition because it provides an overarching interactionist framework that successfully deconstructs the supposed agent-like properties of smaller scale entities such as genes and brains into complexes of multi-scale interactive dynamics. According to this view, the interactionists win out, cognition spreads out across the body–world boundary, and archaeological artefacts constitute the components of cognition.

Upon further reflection, however, it appears that something is missing. For while DST’s untidy ontological framework seems to successfully address causality, it actually does not address the very properties of cognition and agency that have compelled scholars to use concepts such as information, code and plan. Clark (2001) expresses this concern in the following way:

The image of brain, body, and world as a single, densely coupled system threatens to eliminate the idea of purposive agency unless it is combined with some recognition of the special way goals and knowledge figure in the origination of some of our bodily motions. The computational/information-processing approach provides such recognition by embracing a kind of dual-aspect account in which certain inner states and processes act as the vehicles of knowledge and information.

(Clark 2001, p. 135)

What Clark seems to be getting at via the use of concepts such as ‘goals’, ‘knowledge’ and ‘vehicles of knowledge and information’ is the idea that there is something about brain dynamics that distinguishes them from other types of physical dynamics. Specifically, Clark wants to model brain dynamics as entailing both *causal* properties (i.e. a brain state can influence another physical state) and *semantic* properties (i.e. brain states entail content—they have meaning), what one might refer to as *causal content*. According to radical interactionism, however, concepts such as goals and knowledge should ultimately be

recast in terms of multi-scale, interaction-driven dynamics. The problem with this manoeuvre, however, as eluded to by Clark, is that it only addresses the causal properties of such a dynamics. It, in no way, addresses their semantic properties.

To be sure, radical interactionists such as Oyama (1985) and van Gelder (1998) do have a point, and they are not alone, for the notion of internal causal content has been under attack for some time (e.g. Searle 1980; Chalmers 1996). However, herein lies the rub. For while radical interactionism successfully dismantles agent-based accounts of larger scale order, it does so by ignoring the semantic properties that seem to actually define cognition agency (Pacherie 2007). While the internalists, who rightly reject radical interactionism due to its failure to address cognition’s semantic properties, see no way of conceptualizing agency and its associated content without positing internalized, content-bearing vehicles that, in the end, do not stand up to the scrutiny of radical interactionism.

In light of this apparent stalemate, the purpose of the present paper is to describe an approach to agency, what I refer to as wild systems theory (WST; Jordan 2003a, *in press*, *submitted*; Jordan & Ghin 2006, 2007) that posits an account of the semantic properties of agentic states, how they emerged and how they were extended, while simultaneously doing justice to radically interactionist concerns about conceptualizing such states within a mind–world dichotomy that ultimately isolates them internally and, as a result, renders them conceptually lacking.

2. WHAT IS A WILD SYSTEM?

WST begins its approach to agency by conceptualizing organisms, not as computational systems or physical–mental systems, but as open systems (i.e. far-from-equilibrium, energy-transformation systems) that must intake, transform and dissipate energy in order to sustain themselves (Boltzmann 1905; Lotka 1945; Schroedinger 1945; Odum 1988; Vandervert 1995; Boden 1999). In addition, the context in which organisms are embedded (what is traditionally referred to as an ‘environment’), is conceptualized as a self-organizing, energy-transformation hierarchy (Odum 1988; Vandervert 1995). What this means is that the natural world is conceptualized in terms of energy-transformation, such that plants are described as systems that sustain themselves via the intake and transformation of electromagnetic radiation into chemical energy, while herbivores constitute systems that sustain themselves on the chemical energy encapsulated in plants. Such an energy-transformation hierarchy is self-organizing because the structures within it emerge out of the dynamic interactions of properties within the system itself, and it is hierarchical because the availability of particular types of energy (e.g. availability of chemical energy in plants) affords the emergence of systems capable of sustaining themselves on such energy.

Within an energy-transformation hierarchy, survival (i.e. sustainment) requires that energy-transformers be capable of generating outcomes such as capturing fuel

sources and avoiding predators. To do so, they must be further capable of generating coordination among the multi-scale systems of which they are constituted (e.g. neurons, neural networks, brains and bodies). Each of these different levels of scale (i.e. neurons, neural networks, brains and the body as a whole) has its own intrinsic dynamics. The spatio-temporal scale of neuronal dynamics, for example, and the factors that influence such dynamics (e.g. neurotransmitter gradients, synapse densities and the rate of orthograde and retrograde axoplasmic transport) are nested within, yet different from the dynamics of factors critical to the generation and sustainment of neural networks (e.g. neurogenesis (Edelman 1989) and cell assembly formation (Hebb 1949)). Likewise, the dynamics of both of these scales are nested within, yet nonetheless different from sustainment dynamics at the behavioural scale (e.g. behavioural selection and sustainment via reinforcement and punishment, respectively).

Achieving coordination among these multi-scale systems is continuously challenged by the fact that the dynamics at each level fluctuate continuously because (i) they are open to the flow of energy and matter, (ii) the matter–energy context in which they are embedded constantly fluctuates, and (iii) the system's dynamics influence themselves recursively. That is, each level of scale embodies its own history.

To meet the challenge of continuous, recursive multi-scale fluctuations, each level must be capable of addressing the perturbations to sustainment at its own unique level. This is what is meant by referring to such systems as *wild* systems. They must be able to address multiple scales of fluctuation *continuously* while simultaneously achieving coordination as a collective whole. Only then will they be able to produce sustainment-appropriate outcomes. In short, their moment to moment collective dynamics must be a reflection of the open (i.e. wild) multi-scale field of perturbations in which they are embedded.

3. ACQUIRING WILD AGENCY: CAUSALITY AND SEMANTICS

WST's conceptualization of wild systems as multi-scale open systems is consistent with Oyama's (1985) radical interactionism. Causality at every level of scale is synergistically coupled both internally and externally (including the environmental context in which the system is embedded). But while this focus on multi-scale causality ultimately leads radical interactionism to avoid the semantic properties of certain types of wild systems (i.e. brains), WST's emphasis on sustainment within an energy-transformation hierarchy provides insight into certain unique causal properties of wild systems that, in the end, provide a means of addressing their semantic properties.

(a) *Wild agents as hierarchies of self-sustaining work*

A unique causal property of wild systems is that they are able to sustain themselves in an energy-transformation hierarchy because their multi-scale dynamics are *self-sustaining*. That is, their dynamics produce products

that sustain the dynamics that produced the products. At the chemical level, this recursive process is known as *autocatalysis* (Kauffman 1995). When a catalyst is produced by the very reaction it catalyses, the reaction, in essence *catalyses itself* (i.e. it sustains itself). At the level of the single cell, self-sustainment has been referred to both as autocatalysis and autopoiesis (Varela *et al.* 1991; Ruiz-Mirazo & Moreno 2004).

According to Jordan & Ghin (2006), single cells are self-sustaining in that there is an autocatalytic micro–macro synergy between the internal dynamics of the cell and the cell–environment dynamics of the cell as a whole (see Jordan & Ghin (2006), for an explanation of why they focus on autocatalysis versus autopoiesis). That is, the system is able to affect sustainment-producing changes to its relationship with the environment (i.e. attain sustenance) because the internal dynamics are coupled in such a way that fluctuations in the cell's fuel supply give rise to phase transitions in the macro-level whole (e.g. swimming and tumbling) that potentially increase the system's fuel supply (e.g. the cell ends up at a new location in a concentration gradient of nutrients). As a result, the work of the micro–macro synergy produces products (i.e. sustenance) that sustain the work of the micro–macro synergy.

At the level of the neural network, Hebb (1949) and Edelman (1989) recognized that neurons *sustain themselves* by forming connections with other neurons and becoming embedded within a neural network. Neurons that do not embed within a network die off. In short, the *work* of being a neuron (e.g. forming synapses, generating action potentials and engaging in axionic transport) is self-sustaining.

At the behavioural level-of-scale (i.e. the organism–environment level), Skinner (1976) recognized that *behavioural work* is self-sustaining. That is, behaviours are maintained within an organism's repertoire as a function of the products (i.e. outcomes) they produce, with reinforcing and punishing outcomes being sustained and deselected, respectively.

In a nutshell, wild agents are multi-scale open systems which are able to maintain their structural integrity because their multi-scale dynamics are self-sustaining. In addition, the work taking place among these multi-scale nested systems is recursively self-sustaining, what Bickhard (2001) refers to as recursively self-maintaining. For example, when one engages in the behavioural work of consuming an apple (i.e. finding it, picking it and eating it) the behavioural work (i.e. finding, picking and eating) produces a product (i.e. the release of chemical energy in the apple) that sustains the systems (e.g. neurons, neural networks and muscles) that made the behavioural work possible in the first place.

Jordan & Ghin (2006) assert that the emergence of such systems constituted the emergence of *natural intentionality*, in that, the micro–macro synergies of such systems are *inherently* end-directed towards self-sustainment. That is, they are capable of offsetting perturbations to the sustainment of the macro–micro synergy. Given that each level of self-sustaining work in a multi-scale self-sustaining system (e.g. neurons, brains and behaviours) must be able to offset perturbations to the work at that level of scale, each

level is inherently end-directed and, therefore, *naturally intentional*. This leads to the assertion that wild agents constitute hierarchies of nested intentionalities.

It is in this sense that WST conceptualizes organisms as natural, wild agents. Not in the sense that smaller scale internal dynamics code for larger scale dynamics, as is the case in internalist approaches to agency. But rather, in the sense such systems constitute a nesting of multi-scale self-sustaining dynamics. It is the inherent end-directedness of these self-sustaining systems that, according to WST, qualifies such systems as agents.

WST's approach to agency addresses DST's concerns about conceptualizing agency in terms of small-scale 'pre-specifying' structures, for WST posits no such entities. Rather, by focusing on the unique self-sustaining causal properties of wild systems, WST provides an approach to agency that conceptualizes it in terms of multi-scale dynamic interactions. The key insight is that in wild systems, such dynamic interactions are self-sustaining and, as a result, inherently intentional (i.e. end-directed). That is, the intentionality does not reside in smaller scale, pre-specifying codes. Rather, it resides in the self-sustaining, causal properties of such systems.

(b) *Wild agents and their semantic properties*

Jordan & Ghin (2006) propose that the unique, self-sustaining causal properties of wild agents can be used to explain their semantic properties. Specifically, they argue that wild agents constitute *embodiments* of the multi-scale open contexts (i.e. the energy-transformation contexts) that afford their emergence and sustainment. What this means basically, is that wild agents are *naturally* and *necessarily* 'about' the multi-scale energy-transformation contexts in which they sustain themselves. They are naturally and necessarily about such contexts because their multi-scale dynamics are a reflection of the contexts that have persisted (i.e. in which they have been embedded) over the course of both their species' emergence (e.g. the persistent presence of contexts such as fuel sources, oxygen and predators) and their own individual emergence (i.e. the persistent contexts in which the individual wild system has had to sustain itself), what are typically referred to as the phylogenetic and ontogenetic time scales, respectively.

This notion of *embodied context* should not be confused with internalism. Rather, it is more consistent with Oyama's (1985) notion of a developmental system, the idea being that organisms inherit not only their genes but also the multi-scale contexts in which the interactions necessary to the emergence of a phenotype are possible (e.g. the persistence of contexts entailing available food, clothing, shelter and other organisms). Claiming that wild agents constitute self-sustaining embodiments of their developmental contexts and are therefore naturally and necessarily about these contexts is not the same as claiming their internal dynamics code for or 'represent' external dynamics. 'Aboutness' only translates to 'code' when we make internalist assumptions like 'vehicles of content'. All aspects of a wild agent are necessarily about the nesting of contexts that constitute both the agent and the context in which it is embedded (i.e. the developmental system). It just so happens, however, that different internal contexts (e.g. stomachs versus brains)

are coupled with embedding contexts in different ways, and it is the nature of these couplings that gives rise to the different types of aboutness entailed by such systems.

4. EXTENDING WILD AGENCY

Given that wild agents constitute embodiments of context, they can be conceptualized as *world-in-world*. That is, the natural homology of organisms and the contexts they embody indicates that wild agents do not need to be 'informed' about the context in which they are embedded (i.e. their environment) in order to be about it. They are naturally and necessarily about it. This means that by being world-in-world, no epistemic gap exists between an organism's embodied contexts and the contexts in which it is embedded. As a result, there is no need to posit 'content vehicles' that serve the dual purpose of being both causal and semantic. In addition, there is no longer any need for the input-computation-output approach to cognition that was part and parcel to internalism and its assertion of causal content. Instead of the concepts perception, action and cognition, WST conceptualizes psychological functionality in terms of *scales of sustainment*.

The concept scales of sustainment provides a gradient-oriented approach to psychological functionality, versus the trichotomy-driven approach (i.e. perception, action and cognition) of internalism. In this gradient-oriented framework, the distinguishing feature of an architecture is the distality of the time scales in which a wild agent can sustain coordinations (see figure 1). Whereas a single-cell organism is only capable of sustaining coordinations at the proximal scale (i.e. at its membrane interface with the context in which it is embedded), humans are further capable of simultaneously sustaining coordinations with events at the distal scale (i.e. the immediate environmental context). For example, to dance, one must continuously offset perturbations to balance. This constitutes *proximal* sustainment: the system as a whole is capable of offsetting perturbations to relationships among its nested systems, as well as the immediate context in which it is embedded. To dance in a larger distal context (e.g. dance across a crowded floor towards a friend) one must engage in proximal sustainment while simultaneously doing so in a way that avoids other dancers (i.e. offsets perturbations to one's planned distal outcome). This constitutes *distal* sustainment: the system is able to constrain its proximal sustainment in ways that offset perturbations to distal events the system is working to produce.

In addition to proximal and distal sustainment, humans are further able to engage in *virtual* sustainment. For example, in order to switch from dancing a tango to a samba, one must constrain one's distal sustainment towards producing a samba-like distal pattern versus a tango-like pattern. The switch from one *possible* distal pattern to another constitutes virtual sustainment: the system is able to reconfigure and constrain the possible distal patterns it works to sustain.

To claim such sustainment is virtual is to say it is based on *simulation* (Metzinger 2003; Grush 2004) particularly as regards what cognitive scientists traditionally refer to as *off-line cognition* (Wilson 2002)

Figure 1. According to WST, psychological functionality is described not in terms of action, perception and cognition, but in terms of synergistically coupled scales of self-sustaining effect-control. Such multi-scale effect-control systems are able to sustain relationships with events taking place at increasingly larger spatio-temporal scales ranging from the proximal, to the distal, to the virtual. Given each level of scale is capable of offsetting perturbations, each level is inherently end-directed and therefore, naturally intentional.

because it is about contexts (i.e. events) that are not in the organism's immediate organism–environment context (e.g. memories and thoughts).

To review, WST conceptualizes psychological functionality in terms of synergistically yoked scales of contextual sustainment, and it does so in order to address psychological functionality in a way that is consistent with Oyama's notion of multi-scale interaction, and WST's notion of open, multi-scale systems working to sustain functional coherence (i.e. offset perturbation) at multiple scales simultaneously, both within the system's internal dynamics and within its relation to the multiple scales of context in which it is embedded. Given such sustainment necessitates perturbation offset, proximal, distal and virtual sustainment have also been referred to as proximal, distal and virtual *event-control* (Jordan 2003b). Within WST, sustainment and control are interchangeable, because both are used to denote perturbation offset.

Given this notion of describing the functionality of wild agents in terms of event control, the following will describe the contextual constraints that fostered the emergence of increasingly distal scales of sustainment. While doing so I attempt to describe how, within the framework of WST, external aspects of the sustainment process (i.e. aspects of the developmental system) became constitutive of what internalism would conceptualize as mental work.

(a) *Extending wild agency from proximal to virtual sustainment*

The key factor that seems to have propelled the extension of wild agency from proximal to virtual sustainment was the status of wild agents as energy-transformation systems. This is consistent with modelling wild agents as being nested within a self-organizing, energy-transformation hierarchy (Odum 1988; Vandervert 1995). Specifically, the energy entailed in wild agents was available for 'capture' by another system capable of using that energy to sustain

itself. Doing so, however, required the latter to be capable of overcoming all the contextual factors that needed to be addressed in order to capture the fuel source. Thus, once plant energy was widely available, it provided a context that afforded the emergence of a system capable of sustaining itself on plant energy. From this perspective, herbivores can be seen as embodiments of the constraints that need to be addressed 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. This leads to a continuing recursion on a simple theme; specifically, *the fuel source dictates the consumer*.

According to the principle that the fuel source dictates the consumer, WST asserts (Jordan & Ghin 2006, 2007) that virtual sustainment (i.e. cognition) emerged when wild agents emerged that were able to sustain coordination with events that were not present in their immediate 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 that the lion runs towards a location the gazelle does not yet occupy. In short, it propels itself towards the gazelle's *future*.

The reason that a lion can chase and capture a gazelle is because it has embodied 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 (Kawato *et al.* 1987; Wolpert *et al.* 1998; Desmurget & Grafton 2003; Grush 2004; Newport & Jackson 2006). 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, 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, what are known as forward and inverse models (Wolpert & Kawato 1998; Blakemore *et al.* 2000; Wolpert & Ghahramani 2000; Blakemore & Decety 2001; Knoblich & Jordan 2003; Iacoboni 2005; Jordan & Hunsinger *in press*). And given these cerebral–cerebellar loops influence motor cortex and function at a time scale of 10–20 ms, versus the 120 ms time scale between motor commands and sensory feedback, the system can basically control its propulsion via virtual feedback (Clark 1997; Grush 2004), what Paulin (1993) refers to as dynamic state *estimation*, and Kawato *et al.* (1987) refer to as anticipatory motor error. What is common to the notions virtual, estimation and anticipatory is the fact that they are about the future. And even if it is only a 200 ms pending future, it is nonetheless virtual.

Such aboutness is virtual in the sense it is about future body–prey states. To be sure, it is actually about the entire developmental system in which it is embedded. But given the unique way in which brains are coupled with the developmental systems in which they are embedded, they are able to embed (i.e. embody) regularities of the developmental system and become about those regularities more so than internal contexts that are not coupled with the developmental system in a similar way (e.g. stomachs). In addition, it is possible for the lion to embody such regularities within its brain because neural networks themselves function according to the principle of self-sustaining work (Hebb 1949; Edelman 1989). Thus, since patterns of neural activity sustain themselves, 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. In addition, all of this embodied work is naturally and necessarily about the entire developmental system that has to be addressed in order for the work to sustain itself; from the single neuron, to the neural circuit, to the neuromuscular system, to the organism as a whole. Thus, as stated above, there is no epistemic divide between internal and external contexts (including virtual states)—organisms are reciprocally nested eco-systems of self-sustaining work.

(b) Virtual scale-up requires the sustainment of developmental contexts

From the perspective that the fuel source dictates the consumer, it may seem as though the evolutionary process was one of ‘packing’ more and more external constraints ‘into’ the multi-scale self-sustaining dynamics of wild agents. When used as an account of cognition, this packing perspective might leave one prone to assuming that evolution ‘packed’ cognition into the brain and, as a result, lead one towards internalism. But an examination of the smaller time scales at which wild agents actually sustain coordinations with their context, reveals that much of the work entailed in sustaining coordinations resides in the ability of wild agents to capitalize on the effects they

have on the context in which they are embedded. Colonies of ants, for example, are able to sustain large-scale coordinations because the individual ants both excrete and detect pheromone (Dussutour *et al.* 2004). Thus, by altering their external context (i.e. releasing pheromone) they help generate and sustain the external conditions necessary to both individual and group sustainment.

Consistent with Oyama (1985), these sustained external contexts would constitute aspects of the ants’ developmental system. Also consistent with Oyama, these contexts can function at different time scales. For example, via the release and uptake of pheromones, a colony of termites can give rise to the production of a termite hill (Sulis 1997). Here we have two time scales of *context-generation and sustainment*; specifically, pheromone release and uptake gives rise to stable termite couplings, while collections of coupled termites give rise to the termite hill. Both contexts constitute aspects of the termites’ developmental system because each gives rise to external conditions (i.e. contexts) that afford both individual and group sustainment.

As another example of sustained external context, many species produce auditory alterations of their external context (i.e. generate auditory signals), which have an impact on social organization (i.e. the sustainment of social context). In certain types of insects, for example, generating synchronous or asynchronous sounds is a way for males to compete for females (Greenfield *et al.* 1997; Gerhardt & Huber 2002). In banded wrens (*Thryothorus pleurostictus*), overlapping another male’s call is a way for males to establish dominance and maintain territorial boundaries (Hall *et al.* 2006). And female songbirds which hear their partner lose a vocal interaction are more likely to seek extra-pair copulations (Mennill *et al.* 2003).

The point here is that the scaling up of wild agents seems to have necessitated and entailed the synergistic emergence and sustainment of *coupled internal–external contexts*. In short, wild agents generate and sustain important aspects of their own developmental system. Thus, not only are wild agents naturally and necessarily about the multi-scale contexts they embody, certain of those embodied contexts are about changes in external context brought about by wild agents themselves.

This notion of coupled internal–external contexts is important to understanding the scale-up of virtual sustainment from the 200 ms zebra-future available to the lion, to the infinite possible time scales available to human imagination, for it turns out that in certain primate brains, the cerebellar–cortical circuits underlying virtual sustainment are actually open to direct external coupling with conspecifics. Specifically, cognitive neuroscientists have recently discovered neurons in area F5 of the macaque monkey (*Macaca fascicularis*) that are active both when the monkey performs a goal related action and when it observes another execute such an action (Rizzolatti *et al.* 2002). Using functional magnetic resonance imaging with human participants, Calvo-Merino *et al.* (2005) found a pre-motor activation in the human homologue of the macaque F5 when observers watched video clips of either ballet or capoeira dancers. The degree of activation, however, varied directly with the

observer's level of motor expertise in a given dance form, in that ballet and capoeira experts revealed more activation in response to the dance form in which they were experts, while non-expert dancers revealed less activation, and the level did not vary with the dance type.

Collectively, these data reveal a direct, goal-related internal/external coupling between individuals. That is, when one individual produces a distal event (e.g. cracks a peanut, uses a tool or dances a ballet) the generation of that distal event produces the planning states for generating that the same distal event in the event-control systems of an observer. Elsewhere (Jordan 2007), I have referred to this phenomenon as the coupling of *intentional contexts*. And in addition to the coupling of distal, goal-related intentional contexts, there is evidence of direct coupling of proximal, movement-related control systems (i.e. action systems). Grezes *et al.* (1998), for example, found that if participants are asked to observe meaningless and meaningful gestures (e.g. slicing bread motions with or without the presence of bread), both types of movements activate a common network involved in the analysis of hand movements (i.e. bilaterally, the occipitotemporal junction and superior occipital gyrus, and in the left hemisphere, the middle temporal gyrus and the inferior parietal lobe). Differentially, however, meaningful movements further activated inferior frontal gyrus and the fusiform gyrus, predominantly in the left hemisphere (i.e. areas involved in motor planning and object identification, respectively), while meaningless actions resulted in bilateral activations of the inferior parietal lobe and the superior parietal lobule, as well as the right cerebellum (i.e. areas involved in action planning and generation, what were referred to above as forward and inverse models). Collectively, these findings indicate that the observation of another's movements, even if they are meaningless (i.e. have no obvious distal goal), results in the activation of brain processes one would use to generate those same actions oneself.

This notion of a multi-scaled coupling of intentional contexts is consistent with Iacoboni's (2005) model of imitation. According to Iacoboni, direct-coupling systems, what are referred to in the literature as 'mirroring' systems, constitute an important aspect of one's event-control systems. Specifically, he describes how the two mirroring systems, one located in pars opercularis of the inferior frontal gyrus (i.e. Brodmann area 44, the human homologue of the macaque area F5) and the other in the posterior parietal cortex (i.e. a human homologue of mirroring systems found in the inferior parietal lobe of the macaque), project onto superior temporal sulcus (STS) which, in turn, projects back onto the mirroring systems. Iacoboni asserts that the frontal mirroring system is about the distal goal, and the parietal system, that actions generated to attain the goal. He collectively refers to this neural pattern as an *effference-copy*. He does so because (i) in addition to projecting to STS, the mirroring systems also project onto the motor centres involved in bringing about the actions that will ultimately bring about the distal goal and (ii) it constitutes the plan the observer will eventually use to generate the same proximal and distal effect him/her self.

Iacoboni's referral to this neural activity as an *effference-copy* is revealing because it actually comprises anticipated proximal *effects* and intended distal effects, both of which are virtual and available *in the environment*. That is, producing these effects (i.e. making them occur in the environment) makes one's *anticipated* sensory effects and *intended* distal effect *public*. Thus, one's multi-scale intentional (i.e. planning) states are made public via the multi-scale pattern of effects one consistently generates. As a result, as one consistently produces a pattern of effects, this pattern can be tapped into via the mirroring systems of observers.

According to this notion of coupled, multi-scale, internal/external intentional contexts, it seems to be the case that certain primates constrain and contextualize one another's multi-scale *planning* (i.e. multi-scale virtual) states. Kinsbourne (2002) refers to such coupling as 'resonance' and argues that it constitutes the default value in human interaction. Specifically, Kinsbourne proposes that infant imitation is actually uninhibited perception 'on the fly'. That is, as a carer generates action-effect contingencies in an infant's presence, the natural, multi-scale coupling of intentional contexts results in the infant generating the same action-effect contingencies, of course to the extent the infant possesses those action-effect contingencies in his/her repertoire. Only as the cortex develops inhibitory circuits, Kinsbourne argues, are we able to 'not' resonate to the action-effect contingencies 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 resonances. While the former refers to the ability of an organism's body movements to entrain similar movements in conspecifics (e.g. a school of fishes moving together or a flock of birds flying together), the latter refers to resonance at the level of goal related actions (e.g. a chimpanzee watching another eat a peanut, or a person watching another dance).

Collectively, the positions of Kinsbourne (2002), Rizzolatti *et al.* (2002) and Iacoboni (2005) are consistent with WST's assertion that human functionality entails the synergistic emergence and sustainment of *coupled, multi-scale, internal/external intentional contexts*. Given that these contexts are virtual (i.e. they are about *pending* actions and pending distal goals), humans can be said to be directly coupled at multiple levels of sustainment (i.e. proximal and distal) simultaneously. This natural multi-scale coupling afforded the scale-up of virtual sustainment because it was recursively self-sustaining. Again, this means that the work of engaging in multi-scale intentional coupling produced products that sustained such coupling. This requires explanation at both internal and external time scales.

As regards the internal scale, as has already been mentioned, neural networks emerge and function according to the principle of self-sustaining work (Hebb 1949; Edelman 1989). Thus, regularities embodied in self-sustaining neural dynamics are available for capture by newly emerging neural networks (Grush 2004). The aboutness of these new circuits will necessarily constitute an abstraction from

the aboutness embedded and sustained in the network it is tapping into. As regards the external scale, the human ability to couple multi-scale intentional contexts further afforded, when coupled with the plasticity of neural networks, the ability to embody regularities generated in these intentional contexts. Example of such regularities would be gestures and/or vocalizations that repeatedly occurred during the sustainment of multi-scale intentional contexts (e.g. moving things together). As these regularities came to be associated (via neural embodiment) with the intentional contexts in which they occurred, they could then be generated intentionally as a means of more efficiently altering or varying the type of intentional contexts being sustained. These externalized regularities would be more virtual than the intentional contexts from which they had been abstracted, because they would be about *possibilities* for such intentional contexts. And they were (and still are) self-sustaining because by having a means of anticipatorily organizing intentional contexts, groups are able to get more energy per unit work (e.g. capture more prey during the hunt).

As an empirical example of this ability to abstract from sustained intentional contexts, Galantucci (2005) placed pairs of participants in a virtual game environment and required them to find one another. The participants were isolated from each other, and the only way they could communicate was to generate patterns of stimuli via stencil marks on a digital sketch pad. The actions required to make a mark on the stencil, however, were decoupled such that holding the stencil in a fixed position on the pad eventually resulted in a vertical line on the pad because the *y*-axis values of the stencil position were continuously decreased. Once the *y*-value equalled the lowest *y*-coordinate on the sketchpad, the point in the trace vanished. Thus, three quick taps on the same pad location resulted in three vertically aligned dots, while marking a horizontal line from left to right with the stencil resulted in a line that sloped upward from left to right across the pad, yet gradually disappeared (as the *Y*-coordinate values continued to decrease).

Galantucci created this paradigm as a way to investigate participants' ability to generate a sign system within the constraints entailed in the dynamics of the sketch pad. Decoupling the actions from the effects they produced in the communication medium (i.e. the sketch pad) prevented pairs from using previously known signs, while the relatively quick disappearance of the trace mimicked the relatively rapid decay of spoken signs.

Pairs that solved the problem (i.e. continuously found one another) were able to do so because they learned to generate a sign system that allowed them to indicate their pending moves to one another. According to WST, the participants were able to generate sign systems because the signs were constituted of *intended distal effects* (i.e. patterns on the sketch pad) which, by virtue of being consistently paired with other distal effects (i.e. members of the pair found each other or not), came to represent the participants' *planned* move on a pending turn. (Of course, this is just one of many possible meanings a sign could have.) Given these distal events (i.e. signs) referred to states that

were *not in the immediate context* (i.e. planned moves and pending turns) they constitute virtual content. In short, members of the pair were generating distal effects (i.e. signs) that afforded each with the opportunity to contextualize and constrain the other's virtual event-control (i.e. thoughts or simulations).

The ability to engage in *joint virtual-event control* was meted out over time, via the pair's convergence onto a pattern of distal-effect control i.e. an agreed upon pattern of distal effects that gradually became an agreed-upon *external efference-copy* (i.e. a copy of a plan) of the members' virtual event control. Thus, just as the public display of action-effect regularities affords intentional coupling at the distal scale (i.e. in the immediate environment), continuous pairing of particular distal effects (e.g. a series of marks on a pad) with other distal events (e.g. successful distal outcomes such as finding each other in a virtual game) leads to the former 'representing' possible states of the latter which, in turn, makes possible the public display of *group* intentional states.

These external representations of intentional states constitute a necessary condition for the emergence and sustainment of joint virtual-event control. Thus, just as ant coordination and chickadee coordination necessitate the generation of external pheromone and auditory contexts, respectively, joint virtual-event control in humans necessitates the generation of external intentional contexts. In addition, Galantucci's (2005) data are consistent with WST's assertion that humans were able to generate increasingly virtual intentional contexts because the recursively self-sustaining dynamics of internal neural structure and externally sustained, multi-scale intentional contexts, allowed members to abstract and embody, in neural structure, regularities that emerged across different episodes of intentional coupling. These neural embodiments synergistically afforded additional means of intentionally altering external contexts and giving rise to externalizations that afforded joint virtual sustainment at increasingly distal time scales (e.g. calendars, written languages and mathematics). And again, this scale-up was possible because the work was self-sustaining; that is, the joint virtual-sustainment that gave rise to calendars, written languages and mathematics paid for itself because it allowed groups to acquire more energy per unit work (Odum 1988; Vandervert 1995).

As the scale-up of virtual content continued, the development system in which humans found themselves embedded became increasingly virtual (e.g. the advent of formal education contexts), and sustaining oneself within such increasingly virtual contexts required the ability to distinguish one's own, internally generated virtual contexts (i.e. thoughts) from those in which one was embedded. These are the constraints that I believe forced the emergence of the 'self' (Metzinger 2003; Ghin 2005), as well as the self-other distinction (Jordan 2003b; Knoblich & Jordan 2003; Jordan & Knoblich 2004). In short, the self emerged as foreground amidst a background of virtual others, and it did 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 semantic properties (i.e. its phenomenal properties) as do all

self-sustaining systems; from the fact it is naturally and necessarily about the contexts (i.e. the externalized virtual contexts of others) it must embody in order to sustain itself.

5. CONCLUSIONS

The purpose of the present paper was to address the tensions that exist between internalist and radical-interactionist approaches to cognitive neuroscience, and the implications these different positions hold for our interpretation of the archaeological record. Again, if the clean borders between mind and world implied by internalism prove to be the case, archaeological artefacts constitute products of cognition. If the borders between mind and world are fuzzy and unclear however, as is claimed by radical interactionism, the mind spreads out across the body-world barrier, and archaeological artefacts come to be conceptualized as constituting components of cognition.

WST and the notion of wild agency were presented as a potential solution to this issue. By conceptualizing organisms (i.e. wild agents) as open, multi-scale self-sustaining systems, WST is able to address the causal properties of wild systems in a manner that is consistent with radical-interactionist concerns regarding multi-scale contingent interactions. And by conceptualizing wild agents as self-sustaining embodiments of the persistent, multi-scale contexts that afforded their emergence and in which they sustain themselves, WST is able to address the semantic properties of wild agents in a way that does justice to internalist concerns regarding meaningful (i.e. semantic) internal states (i.e. causal content).

In addition to simultaneously addressing the concerns of radical interactionists and internalists, WST also avoids conceptual dichotomies such as mind-body and mental-physical, as well as the increasingly problematic trichotomy of perception-action-cognition. It does so by conceptualizing psychology functionality in terms of gradients of sustainment (i.e. nested scales of event control). This, in turn, allows WST to see organisms as world-in-world, which, in turn, removes the epistemic gap between organism and environment inherent in physical-mental dichotomies. Given WST's further assertion that the sustainment of world-in-world involves the generation and sustainment of internal-external context couplings, these generated and sustained external contexts (e.g. pheromone contexts, auditory contexts and intentional contexts in ants, birds and humans, respectively) become constitutive of multi-scale sustainment. As a result, the 'anatomy' of multi-scale sustainment spreads out across these internal-external contexts. The anatomy of human intelligence therefore, conceptualized as a virtual sustainment, likewise spreads out across the other relative, intentional contexts groups are able to sustain and generate.

To be sure, one can and should investigate the multi-scale, nested intentionalities of individual wild agents (i.e. neurons, brains, behaviours and thoughts). But when this is done within the framework of WST, one is less likely to miss the multi-scale coupling of internal-external intentional contexts (i.e. what Oyama 1985,

refers to as a developmental system) that allowed such individual abilities to phylogenetically and ontogenetically emerge. This, in turn, leaves one less susceptible to the mind-body, mind-brain conceptual dichotomies that can lead one to isolate mental work within the brain.

Finally, by approaching psychological functionality in terms of the homology of self-sustaining work that extends across the levels of scale investigated by chemists, biologists, psychologists, anthropologists and archaeologists, WST might be particularly well situated to serve as an integrative, interdisciplinary framework for cognitive science. Instead of constituting a science of the mind, however, it would constitute the science of multi-scale open systems. In short, a science of wild agents.

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