Intercactivity and Enaction in Human Cognition

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Introduction

This target article is an effort to come to grips with the relation between interactivity and enaction. The first of these has not been systematically formulated as a distinctive paradigm, but is nonetheless emerging as a vital set of concepts underlying research on cognition and social interaction. This body of research, which we will provisionally refer to as “interactivity-based approaches,” explores ecological, distributed, and bodily aspects of human action and social interaction (Cowley 2011; Cowley & Vallée-Tourangeau 2013; Steffensen 2015). The fundamental commitments of the second — an increasingly influential paradigm for research in cognitive science — are to the inseparability of explanations for cognition from explanations for life, and to the self-producing and self-sustaining organization of living systems as a resource for explanations of both kinds (Stewart, Gapenne & Di Paolo 2010; Thompson 2007). The two clusters of concepts are fairly close relatives because they share many theoretical predecessors. The research programs in which they are involved are also natural allies, as both are actively pushing the explanatory boundaries of non-representational cognitive science, and both take for granted the fundamental importance of embodiment, biological dynamics, and ecological embeddedness in accounting for cognition and agency.

Although the development of enactive theory has been a source of insight and inspiration for our interactivity-based approach, it is not a variety or descendant of enactivism. Our interest in social agency, interaction, and cultural aspects of human life are a poor match for some of the core tenets and concepts in enactivist thought, and we are not fully satisfied with the resources enactivism provides to answer questions in these domains. This dissatisfaction comes primarily from our inability to find, in existing enactivist accounts of social cognition (e.g., Cuffari, Di Paolo & De Jaegher 2014; De Jaegher & Di Paolo 2007; De Jaegher, Di Paolo & Gallagher 2010; De Jaegher & Froese 2009; Froese & Di Paolo 2009, 2010, 2011) any account of the ecological transformation that language and human sociality bring about, which also conditions individual cognitive activity. This lack has its roots in a more fundamental mismatch between en-
activist and interactivity-based assumptions about the basic nature of relations between agents and their environments. In general, where enactivism describes agent-environment relations in terms of in-the-moment coupling, we assume these relations play out on multiple heterogeneous timescales, such that in many cases – perhaps most – agency is fundamentally distributed.

« 3 » This difference is most easily brought out in the following way. When one begins with human action as an object of study, it is immediately apparent that it cannot be exhaustively explained in terms of the coupling of bodily movement to surfaces of the environment. This is usually because the action being studied in some way directly depends on customs, objects, experiences, and events that are outside its immediate spatiotemporal scope. For instance, re-conceptualization can lead someone to perceive previously unnoticed affordances of an otherwise unchanged material setting, or the discovery of small, unexpected sensorimotor contingencies while interacting with technology can refocus their attention, their efforts, or their thinking about the situation. “Interactivity” arose as a way of talking about the potential for this type of person-environment engagement possessed by particular artifacts, or spaces, or problems, and has in general been used to refer to a research interest rather than a specific theoretical construct. Its original and most frequent use is in the study of human-computer interaction, where it picks out an interest in the small-scale contingencies of action–perception cycles in coupling to technological interfaces (Johnson, Bruner II & Kumar 2006; McMillan 2006). More recently, it has been borrowed by scholars interested in distributed cognition to name a related, loosely-defined, class of phenomena that includes the small-scale dynamics of engagement with artifacts and other people in problem solving, professional settings such as offices and emergency rooms, and more bodily practices such as choreography and jewelry-making (Baber, Parekh & Cengiz 2014; Cowley & Nash 2013; Cowley & Vallée-Tourangeau 2013; Kirsh 1997, 2015; Pedersen 2012).

« 4 » Development of interactivity as a concept has been slow to follow its use as a topical designator, but several recent papers (Steffensen 2015; Steffensen & Pedersen 2014; Steffensen, Vallée-Tourangeau & Vallée-Tourangeau 2015) have made headway in this regard, linking interactivity to multiscalar dynamics of the cultural, historical, and ontogenetic contexts in which human action is embedded. By way of contrast with enactivism, approaches based on this notion of interactivity begin with the ecological embedding and social normativity of human action, and then seek to understand its biological nature, rather than looking for purely biological explanatory principles.

« 5 » The rest of the article takes the following course. In the next section, we will lay out our understanding of enactivism as a research paradigm, noting points of agreement and detailing the enactivist position on issues important to our comparison, which have primarily to do with Varela-inspired concepts such as autonomy, adaptivity, and sense-making. The subsequent section presents our concerns with that position, which are

- that it mis-characterizes the organization of many living systems by inadequately accounting for the constitutive role of environmental structures and socially normative patterns of behavior, and
- that it incorrectly ascribes sense-making to intrinsic teleology on the time-scale of an organism’s biological self-maintenance, which we take to be far too narrow a characterization of the relevant sources of constraint and normativity.

In the section “Interactivity,” we build up a clearer notion of interactivity as sense-saturated coordination that enables and contributes to human action, and then explore how this notion can be made both richer and more precise. We conclude with a summary of the points of agreement and divergence between our position and post-Varela autopoietic enactivism.

Varieties of enactivism

« 6 » The terms “enaction” and “enactive” were first used in something like their current sense in Francisco Varela, Evan Thompson, and Eleanor Rosch’s (1991) The Embodied Mind. That book was both influential and to a large extent successful in its effort to place first-person experience and systems-theoretic biology at the cutting edge of “the new sciences of mind,” by which bold phrase the authors meant the inchoate collection of ideas and methods that were opposed to the cognitivist tradition in cognitive science. These are now widely referred to by the catch-all label “4E cognition,” where the four Es indicate interest in embodied, embedded, extended, and enacted aspects of the function of cognitive agents (Menary 2010; Rowlands 2010). As we see it, “enactivism” is a heterogeneous subset of contemporary 4E approaches to the study of mind and agency, distinguished either by their acceptance of the notions of autopoiesis and autonomy (e.g., Barandiaran & Eigbert 2014; Barandiaran, Di Paolo & Rohde 2009; Di Paolo 2009b; Froese & Gallagher 2012; Froese & Ziemke 2009; Froese, Virgo & Ikegami 2014), due to Varela’s work with Humberto Maturana (Maturana & Varela 1980, 1987; Varela 1979), or by their concern with phenomenology and lived experience (e.g., Colombetti 2014; Degenaar & Myin 2014; Gallagher & Hutto 2008; Noë 2009; Ratcliffe 2012), or both.¹

« 7 » Many of these approaches are historically non-central varieties of enactivism in that they are (or are in part) direct intellectual descendants of Varela, Thompson, and Rosch, but are not focused on developing their central ideas. Being in a similar theoretical situation ourselves, we are sympathetic to such approaches; two in particular – often called “sensorimotor” and “radical” enactivism, respectively – are helpful in spelling out our own position. After briefly discussing these, we will turn toward the paradigm’s “primary literature,” composed of the original work of Maturana and Varela (identified as such by e.g., Di Paolo 2005, Froese & Stewart 2012). Our overview will follow a roughly chronological course, beginning with Maturana’s biology of cognition and the original notion of autopoiesis, which we understand as a non-explanatory abstract description of the organizational characteristics of living systems. Varela’s

¹ We will use the phrase “lived experience” to indicate the phenomenal, experiential character of organisms’ engagements with the world, from their own “first-person” point of view.
work diverges from Maturana’s in at least two ways:  

a. it moves towards formally rigorous systems-theoretic accounts of autonomy and so also towards a conception of autopoiesis as a specific sub-category of autonomous systems; and  

b. it introduces the ideas of intrinsic teleology and normativity, and enaction as sense-making (from which comes the idea of “life-mind continuity”).

These changes formed the basis for the logical extension of autopoiesis that we refer to here as “post-Varela autopoietic enactivism,” and which is exemplified by the work of Ezequiel Di Paolo, Tom Froese, Hanne De Jaegher, John Stewart, Xabier Barandiaran, and others. This section is intended expositionally; we will argue in subsequent sections that both aspects of the turn towards post-Varela enactivism are problematic, and also that they introduced claims that are incompatible with interactivity in ways that Maturana’s original work is not.

**Sensorimotor enactivism**

8 One of the best-known strands of enactive research concerns the inseparability of action and perception. The core insight of “sensorimotor enactivism” (O’Regan & Noé 2001a, 2001b) is that for organisms with nervous systems, motion is always directly regulated by sensation, which is itself structured and given its character by the dynamics of bodily movement in relation to the organism’s environment (for overviews, see Hurley 2002; Noé 2004; O’Regan 2011). Perception is active and virtual, by which it means that it depends not only on current sensation but also on the way sensation, and current movement, is systematically related to upcoming and potential sensory events, on the basis of the structure of the environment and the organism’s neuromuscular expertise (Mossio & Taraborelli 2008; Noé 2012). This expertise comprises anticipatory sensitivity to the contingencies of sensory events in relation to potential or ongoing bodily movement, and is developed by means of individually and socially regulated experiences during ontogeny (for discussion, see Buhrmann & Di Paolo 2014: 21–31; Buhrmann, Di Paolo & Barandiaran 2013; Hutto 2005; Loughlin 2014).

9 Sensorimotor theory is enactivist in at least three ways. First, it contradicts the cognitivist model of perception as the input of information, which, after being suitably processed, might be used to choose a suitable course of action-output. In the sensorimotor enactivist view, action and perception are inextricable, and perception constitutively involves both sensorimotor skill (which is therefore not a separate type of non-perceptual information processing) and elements of the environment that partly specify sensorimotor contingencies (see e.g., Barandiaran 2012; Hurley 2001; Gangopadhyay & Riverstein 2008; Prinz 2006).

Second, the approach is centrally concerned with first-person lived experience, which it understands in terms of the active use or application of bodily sensorimotor expertise to engage with the world; this makes it closely allied with the phenomenological aspect of Varelian enactivism (Myin & O’Regan 2002; O’Regan, Myin & Noé 2005). And third, given these two similarities, sensorimotor theory can be understood as a partial interpretation, in concrete biological terms, of the core idea that organisms “enact,” or actively construct, the world from their individual perspective (Noé 2012: 58f; O’Regan & Noé 2001a: 945; Thompson 2005, 2007: 254–265).

10 Our understanding of sensorimotor enactivism is that it is a description of how organisms with nervous systems engage perceptually with their worlds. We take it to be a non-exhaustive and very general but nonetheless scientifically robust account of the mechanisms involved, one that we see no reason to reject and every reason to support. In fact, the notions of interactivity, distributed cognition, and so on are very difficult to make sense of without some version of a sensorimotor account of perception and action (Cowley 2009; Cowley & Vallette-Tourangeau 2013; Rączaszek-Leonardi & Cowley 2012; Thibault 2011).

**Enactive anti-representationalism**

11 We are similarly in almost complete agreement with “radical enactivism,” as described and defended by Daniel Hutto and Erik Myin (2013; see also Hutto, Kirchoff & Myin 2014; Hutto 2013; Hutto 2015). Their “enactivism” is self-professed, and consists entirely of the claims that:

a. agency and cognition are fundamentally a matter of dynamical bodily engagement with the world; and  

b. the notions of content and representation are not naturalistic and so cannot be used in naturalistic explanations.

The first of these is a straightforward commitment to the embodiment of cognition rather than a strictly enactivist thesis, and so the authors write that they “remain neutral toward other, more extravagant claims associated with the original version of enactivism” (Hutto & Myin 2013: 5). The second claim amounts to a consistent, technically sophisticated philosophical anti-representationalism, whose core is the “Hard Problem of Content.” It can be informally summarized as follows:

- Any valid explanation of cognition must be naturalistic.
- The idea of “representation” minimally requires positing a state or structure that bears “content.”
- Therefore representational theories of cognition are predicated on the claim that content is a naturalistic property or substance.
- All serious attempts to account for content in naturalistic terms have involved treating it as a kind of information, but information-as-content (which is the only naturalistic kind of information) lacks the minimal properties necessary for something to count as content.
- Conclusion: representationalism that relies on information-as-content is not naturalistic, and therefore cannot offer valid explanations for cognition.

This is probably the most contentious part of the argument, as many philosophers follow Fred Dretske (1988) and Ruth Millikan (2004) in holding that there are richer, equally naturalistic theories of information. For discussion, see Milkowski (2015a, 2015b) and Myin & Hutto (2015).
<12> Interactivity-based approaches are premised on a similar anti-representationalist stance, albeit one that is motivated as much by concerns about explanatory utility as by concerns about philosophical status. Because of this difference in theoretical motivation, our anti-representationalism is more thoroughgoing than that of “radical enactivism.” Hutto and Myin hold, as we do not, that any cognitive activity that is both phylogenetically and ontogenetically subsequent to the development of “natural human language” is likely to be representational and content-involving (e.g., Hutto & Myin 2013: 41, 151–153; see Harvey 2015 for in-depth discussion, and cf. Hutto & Satne 2015; Kiverstein & Rietveld 2015). We agree with them that the directedness of activity inherent in biological self-maintenance (Di Paolo 2005; Thompson 2007: 140–148; Weber & Varela 2002) is not of the rule-following type usually described as “normativity” and that is often taken to characterize language (Hutto & Myin 2013: ch. 2; cf. De Jesus 2015; Heras-Escribano, Noble & De Pinedo 2014). And further, we agree that conventions, rules, and so forth are uniquely social and have to do with inter-agent coordination. But it does not seem to us that this justifies calling them representational or contentful. On the contrary: one of our core assumptions is that “representation” and associated concepts are exactly as explanatorily vacuous when invoked to account for socially situated activity as they are when invoked to account for the behavior of simple organisms.4

Maturana

<13> Here we turn to the historical roots of enactivism. In the 1970s and 80s, Humberto Maturana articulated a series of concepts that he regarded as useful in understanding the relation of biology to human knowing and engagement with the world. Very roughly, these include an epistemology and implicit ontology (the observer, structure determinism), a model for scientific explanation (in terms of distinctions, unities, and generative mechanisms for phenomena), an abstract characterization of the organization of biological systems at the molecular level (autopoiesis), and an equally abstract conception of cognition in terms of organisms’ experience of being coupled to the world. Some of these lose their intended meaning if considered apart from the others; in particular, autopoiesis must be understood in terms of Maturana’s model for scientific explanations. The concept of autopoiesis

- specifies the organization of living systems, and
- grounds and justifies Maturana’s ontological and closely connected epistemology.

<14> It is necessary to begin by distinguishing “organization” from “structure,” on the one hand, and from “operation,” on the other. Organization is an abstract specification of the set of relations that obtain among the system’s repeating component processes so long as the system persists. A system’s organization produces the properties that define it as a member of a particular type or class of system for an observer, and also “defines it as a composite unity.” Structure is the set of processes or components that in fact realize a given system’s organization at a particular point in time (Maturana 1978: 32f; Maturana & Varela 1980, 1987: 42–52; Varela 1979: 8–11). The way Maturana uses the terms, both organization and structure are defined as abstractly immediate, which is to say, it is assumed that the relations comprising a given organization or structure are dynamic ones, but the scales, rates, and so forth on which they play out are not specified. For this reason, it is important that we separate a system’s (static) organization from its operations, that is, the actual realization of its component processes as they play out over time, and their causal effects on one another and on system-external processes.5

<16> The ontological and epistemological nature of the concept comes from the additional notion of “autonomy,” which is introduced to thematize the fact that molecular events that affect a cell (without destroying it) will have their effects according to the cell’s self-production. Whatever the effects are—a change in cytoplasmic salinity to match the salinity of the extracellular milieu, say—it will be determined by the way the change affects the cell’s autopoietic organization (Maturana 1970: 17f; 1978: 36f). “Autonomy” gives a name to this partial organizational independence; its conceptual purpose is only to highlight an aspect of autopoiesis (Maturana & Poerksen 2004: 68–81). When Maturana says
(as he does frequently) that autonomy is a more general notion than autopoiesis, he means that autopoiesis is a description of the reason why (and the way in which) living systems are autonomous in this general sense (Maturana 2011). So the autonomy of living systems does not amount to their static molecular self-organization regulating all constitutive operational dynamics of the system. It amounts, instead, to the claim that no external constraint can affect its activity in a way that is somehow irrespective of the interdependence among its component molecular processes.

This point about autonomy brings up a more general aspect of Maturana’s work, which is that because it is strictly abstract, strictly synchronous, and bound up with non-systems-theoretic epistemological and ontological assertions, it makes no particular claims about the operational dynamics of living systems. For instance, Maturana writes of an organism’s surroundings simply as its “medium,” not bothering to differentiate it or speak of its structure or role; what matters to him is only that that structure will always affect the agent in terms of the agent’s organization. And so it seems to us that examples of circular molecular organization might, without contradiction, be realized operationally by non-circular, constitutively open and environment-involving, massively distributed and multi-scalar processes. For instance, both eating and breathing are ways of maintaining organizational closure on the molecular level, but they do so irregu-
larly, over far longer timescales than those on which metabolic processes play out. When we refer to Maturana in the rest of the essay, we will have in mind his position construed in this way.

Poerksen interviews, human autonomy is not equated with operational self-sufficiency but rather with moral responsibility (Maturana & Poerksen 2004: 74f). And, in his initial paper on the biology of cognition, the word “autonomy” appears only once, in the post-scriptum, where Maturana writes, “man is a determinism and relativistic self-referring autonomous system whose life acquires its peculiar dimension through self-consciousness” (Maturana 1970: 26).

Varela

As Di Paolo (2009a: 11) tells us, “enaction, Varela-style, starts with the question of the autonomy of the cognizer.” Although they worked together very closely, Varela’s approach to autopoiesis and autonomy seems never to have been perfectly aligned with Maturana’s. As early as 1979, Varela was focusing on autonomy as an operationally defined systems-theoretic concept. That is, he understood it as a claim about the dynamics of a system as it realized itself over time, and also as an aspect of the systems-theoretic composition of organisms, rather than as a way of talking about a basic, non-generalizable condition of all living.

There are several elements of this change (see Varela 1979: 52–57). First, Varela defines autonomy as the ability of a system to delineate itself in some domain by means of its “organization and operation,” in such a way that an observer can identify it through coupling to it in that same domain. For instance, we can identify cells through being coupled to them in the molecular domain. Second, Varela defines circular self-realization in terms of (what we would call, given the terminology we are using here) operational closure, rather than closure of static organizational relations. To quote him at length:

We shall say that autonomous systems are organizationally [in our terms, ‘operationally’] closed. That is, their organization is characterized by processes such that (1) the processes are related as a network, so that they recursively depend on each other in the generation and realization of the processes themselves, and (2) they constitute the system as a unity recognizable in the space (domain) in which the processes exist. Once this circularity arises, the processes constitute a self-computing organization, which attains coherence through its own operation, and not through the intervention of contingencies from the environment. (Varela 1979: 55, emphasis added)

This reflects a general shift to thinking of autonomy as a technical concept for the analysis of systems, a shift that is realized in various ways. For instance, Varela (1979: ch. 11–13) expends significant effort in developing a formalization of autonomy in systems-theoretic terms, and for the same reason, he is led to treat “autopoiesis” as a formal specification of a subset of autonomous systems, and autonomy as the general case of autopoiesis. He suggests that examples of other types of autonomous systems might include social units such as families, companies, and ecosystems, provided that they display operational closure in some appropriate non-physical domain (ibid: 53). All of this supports our conclusion that, in the above passage, Varela is suggesting that autonomous systems are not only organizationally closed in the static, abstract, and non-specific sense proposed by Maturana, but also closed in their actual dynamic processes of self-realization (i.e., their operation). The interpretive move we made with Maturana – to construe his organizational account as compatible with a wide range of distributed and heterogeneous operational dynamics – is thus not open to him.

Varela’s thought also moves away from Maturana on the relation of cognition and experience to autopoiesis. In his later work, he developed a view of autonomous systems as immanently (i.e., intrinsically) purposive, in the sense that if a network of processes is self-realizing, the operations of those processes must – as a matter of necessity – be such that they maintain the overall organization of the system. This idea comes from Varela’s application of Kantian philosophy to his pre-existing views on autonomy and autopoiesis, a process summarized in Andreas Weber and Varela (2002). Thompson (2007: 146) explains that over time, Varela “came to believe that this notion of immanent purposiveness is not simply descriptive but explanatory,” in that it helps to educe an additional aspect of the logic of autonomy. For a system to be autonomous is for it to create itself as a stable “identity” among fluctuations of matter and energy. To
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have an identity is to have established “a logical and operational reference point” for one’s engagement with the world, which engagement is therefore (again, necessarily) conducted in accordance with the needs specific to one’s particular manner of self-creation (Varela 1991, 1992, 1997). Varela used the term “sense-making” for engaging with the world in this intrinsically intentional way.

So in our view, Varela’s work represents two trends away from Maturana. These are:

- a new understanding of “autonomy” in technical, systems-theoretic terms, which leads to a construal of autopoiesis as a subset of autonomy; and
- a model of cognition as the way an organism (or agent, or person) operational closure constrains its interactions with its environment.

Post-Varela autopoietic enactivism

Both of these trends are carried forward by the strand of thought that we call “post-Varela autopoietic enactivism,” which is what we will refer to from here on when we use the word “enactivism.” For instance, Ruiz-Mirazo and Moreno (2012) refer to Varelian autonomy as “the core of life” and see it as the key to explaining evolution. Thompson (2007: 44) places Varela’s account of autonomy at the heart of his account of cognition. And for De Jaeger and Di Paolo (2007), coupling between autonomous agents is the basis for explanations of social interaction. The clearest development of these trends is a line of research that begins with Di Paolo’s (2005) observation that when construed in formal, systems-theoretic terms, autonomy is actually insufficient to entail the logic of sense-making (see also Thompson 2004). In particular, a network of processes that displays bare self-maintenance – call this “minimal autonomy” – does not, simply by virtue of that property, have the ability to continue to maintain itself when perturbed, or when its environmental conditions change.

This observation leads Di Paolo to propose a hierarchy of increasingly rich systems-theoretic concepts to account for increasingly complex ways that living systems can relate to their environments, which, it should be noted, all describe operational characteristics rather than organizational ones (for a detailed presentation of these see Di Paolo 2015; Di Paolo, Rohde & De Jaeger 2010; Froese & Di Paolo 2009, 2011). “Adaptivity” describes the minimal case of a system that is autonomous and, in addition, can respond to perturbations by modifying its operations so as to keep stable some homeostatic or homeodynamic variable. This selective responsiveness is minimal “sense-making.” “Agency” – or minimal behavior – is adaptivity achieved by means of a system regulating some aspect of its coupling with the environment external to its operational bounds, which it must do according to a “value” or “norm” generated by its manner of self-production. “Mentality” requires that the coupling so regulated be sensorimotor, and “sociality” requires that the system’s intrinsic norms are underdetermined by metabolism (i.e., they concern maintenance of system identities other than bare molecular identity).

Difficulties with agency and sense-making

In this section, we articulate several concerns about the Varelian and post-Varelian enactivist approaches, having to do with agency in general and with the concept of sense-making in particular. But first, let us be clear about what we do not take issue with, as many of the enactive approach’s central commitments are shared by our interactivity-based approach. In addition to our agreement with sensorimotor explanations for perception and with thoroughgoing anti-representationalism, we concur that the study of living systems can and should involve the effort to characterize their organization as well as the dynamics of their biochemical operations. We are convinced – by enactivist research as well as by work in related fields (e.g., Baber, Parekh & Cengiz 2014; Bailly & Longo 2008; Lalandy, Odling-Smee & Feldman 2000; Turvey 2007; van Orden, Holden & Turvey 2003) – that such characterizations comprise a useful, productive, and scientifically valid approach to the study of organisms, agency, and cognition. Additionally, we take it that the lived experience of agents is crucial to any viable account of cognition, human or otherwise, and we wholeheartedly agree with Di Paolo (2005) that cognitive science must use interdisciplinary methods and treat its many objects of study as inherently interrelated. With all of this in mind, there are two specific issues on which our position diverges sharply from that of the enactivist paradigm.

The operational openness of living systems

Our first concern is that most organisms, perhaps all, achieve molecular self-realization in a way that constitutively involves body-environment interactions. That is, (a) the activity of organisms is regulated by influences that are not inherent in either their synchronically defined organization, their immediate sensory array (i.e., that are not immediately present as impingements or perturbations on the system’s autonomy), or the emergent autonomous dynamics of ongoing organism-environment coupling. And (b) organisms rely on these regulatory influences to stay alive, and use them as basic, lineage-general ways of maintaining their molecular self-reproduction. Now, if these situations are simple cases of an organism regulating an environmental feature such that the feature became an enabling condition for some of its body-internal processes, then they would simply involve a mis-match between the spatial and operational bounds of the organism, which is perfectly compatible with the enactivist framework and its model of organism-environment asymmetry (Virgo, Egbert & Froese 2011). Similarly, if they only involve a one-way, transient enabling relation between an organism-external and an organism-internal process, there would be no reason to doubt the underlying stability of operational closure. But it is doubtful whether an operational closure-based account can describe even straightforward phenomena such as nest-building and web-building, where agents’ basic methods of thermoregulation, orienting themselves in space, and internalizing molecules required for metabolism are organized on timescales other than those of bodily motion and molecular production (Sterelny 2010). For instance, if members of a species can only reach maturity by growing inside a cocoon, surely past acts of cocoon-building are constitutive elements of their maturational processes. Our first contention,
then, is this: the logic of Varelian autonomy does not work for situations other than monoscalar coupling between an organism and a non-living milieu of some kind. 10

9 The mistake here, as we understand it, is in making an unnoticed jump from autopoietic organizational closure to substrate-general operational closure. The first notion is a Maturana-inspired view along these lines: the molecular processes of synthesis and breakdown responsible for creating the body of any given organism comprise a circularly organized network through their relations of enablement, although the way they enable one another may be indirect (i.e., may involve various other mediating processes that are not processes of molecular production or immediately relevant thereto, and may play out on different spatial and temporal scales). By contrast, substrate-general operational closure (Varelian “autonomy”) describes a situation where the dynamics of the processes constituting an organism—including processes other than molecular production—depend on and condition one another, and enable one another directly, that is, enable one another without depending on non-systemic processes. Whereas (our understanding of Maturana’s conception of) autopoiesis is an abstract conceptual reconstruction of a particular aspect of the way living systems function, and can be realized in a wide variety of ways, Varelian autonomy is a characterization of the defining properties of the system’s actual operational dependencies over time. This is why Di Paolo argues that it has to be augmented with additional requirements and details if it is to be accurately applied to complex organisms. He is correct insofar as autonomy is not an accurate characterization of the operational dependencies among most organisms’ component processes, but incorrect in that he assumes that autonomy always obtains, and that what is needed are details of what the organism does in addition to realizing its operational closure.

10 This is a generalization and extension of the criticism in Cowley and Gahrn-Andersen (2015), which is that autonomy is incompatible with the way that social animals rely on one another—and on history, and traditions, and environmental structures—to organize their actions.

28 It should be noted that both organizational closure and non-autonomous living systems have been recognized as theoretical possibilities in the enactivist literature. Nathaniel Virgo and colleagues define autonomy in terms of a-temporal closure of enabling conditions among repeating processes, rather than in terms of synchronic closure of enabling conditions among processes as they play out in real time. And so they write,

“on this view the autopoietic system that constitutes the [animal] is not coextensive with the unity that we refer to as ‘[the animal]’, it is much bigger. This will be the case for most if not all organisms, since most organisms rely not only on sensory-motor loops that run through their environment but also on nutrients that are recycled externally to them." (Virgo, Egbert & Froese 2011: 246)

If we are careful, we will see that this is a species of organizational closure as we have defined that concept, although their version strongly implies that the processes in question are all on the same timescale and does not allow for constitutive openness of operations. This latter possibility is acknowledged, instead, by Di Paolo (2009b: 63–66), for whom it arises as the idea of a system that is alive without strictly being autonomous. Such a system would be one whose self-production (i.e., metabolism) is organized such that it could only persist in the presence of enabling conditions (e.g., the presence of nutrients) provided by processes of environmental interaction rather than by processes inside the organism’s operational bounds. Where this description applies, the system is literally constituted by environmental interaction. Di Paolo uses a fictional animal to illustrate his point, but any animal capable of taxis would have done just as well: our claim is precisely that this obtains for almost all organisms, and that it should be the starting point for research rather than a mere logical possibility.

29 It is helpful to consider an example in more detail. Scott Turner (2000: 41–51) describes “bioconvection,” in which convection cells emerge in the collective movement of large groups of microorganisms. He uses the example of *Chlamydomonas nivalis*, which swim straight ahead whenever they are in water that lacks sufficient oxygen for their continuing metabolic function, and whose bodies are asymmetrical such that in a still fluid, their massier back ends rotate down beneath them, with the effect that they swim upwards. In an open culture, where oxygen enters the water from the air and slowly diffuses downwards, *Chlamydomonas* cells will swim upwards en masse, concentrating near the surface. This situation is unstable, as it is effectively a fluid whose top layer is much denser than the layers beneath it, so areas with a particularly high concentration of cells will begin to sink. As this “anti-bubble” of microorganisms falls through the fluid, it creates a column of downward-flowing water, which has the effect of rotating the nearby *Chlamydomonas* cells towards the center of the column (again, because their “back” ends have greater mass than their “fronts”), into which they swimming then carries them. This increases the density of the fluid in the middle of the column, causing it to continue to sink, and making the downward-flowing column of fluid into a fairly stable pattern. At the bottom of the culture, the cells disperse and start to swim upwards again, while at the surface, cells are “falling” into the column and drifting downwards. The net effect is that in a suitable environment, simply by swimming forward, a colony of *Chlamydomonas* is able to provide all of its member cells with adequate access to oxygen-rich surface water, allowing their cellular (e.g., metabolic) functions to continue such that they can continue to swim. This seems to us to be a perfect example of how “structural modification of the environment can power a physiological function outside the body” (Turner 2000: 41). In other words, individual *Chlamydomonas* cells are not operationally closed.

30 Our goal here is not to point out an unnoticed biological phenomenon, but rather to highlight a mismatch between well-understood phenomena and the enactive framework for their analysis. The assumption that living systems are all characterized by autonomy seems straightforwardly out of sync with the ways that organisms, and animals in particular, engage with their worlds. This brings out another way of stating our worry: it seems to us that the notion of an ecological niche contradicts the idea that organizational closure...
is always realized by operational closure (perhaps in addition to other operational characteristics). Self-maintenance and agent-level stability can only accurately be ascribed to organism-environment systems, we suggest, and not to organisms in themselves. Granted that organisms do display organizational circularity when this is mapped out on a suitably abstract level, and that epithelial and other bodily boundaries have functional importance, neither operational nor bodily bounds do the job of separating that which constitutes an organism from that which does not, and what actually corresponds to this former category will vary depending on the organism’s ecology. This is our first disagreement with enactivism.

**Sense-making**

« 31 » A closely related worry concerns the logic of sense-making and intrinsic normativity. Enactivism construes organism-environment relations as being “always and everywhere” (to borrow a phrase from Hutto and Myin) a matter of coupling between an individual organism and its current environment that is modulated by the organism with respect to that organism’s intrinsically produced norms (Barandiaran & Egbert 2014; Thompson 2011: 30–43; Thompson & Stapleton 2009: 24f). There may be cases where the logic of this relation applies – the well-worn example of the E. coli bacterium chemotaxing up a sucrose gradient may fit, for instance – but in general it will not, for two reasons. First, what constitutes a “current” environment, and so what counts as organism-environment coupling, depends on what timescales have been selected as focal for the investigation. “Current” means something like “temporally proximal on a given timescale” although the timescale thus indicated

- is usually given only implicitly by selection of experimental apparatus, and so also
- has no necessary relation to the temporal scales specified by the rhythms that characterize the activity of a given organism or lineage (see Cowley & Steffensen 2015).

A second problem comes from the regulatory influence that non-bodily systems and processes can have on (inter-)action. Activity is often organized by norms, such as social norms, that are not intrinsic to any operationally closed system, as well as by the properties of material structures used in particular ways. As an example, consider how both problems apply to the way a spider uses vibrations in its web to detect the location of trapped prey (e.g., Barrows 1915; Barth 1985). In such a case, an organism’s action and sense-making are not, strictly speaking, emergent from the coupling of its body to the environment on the timescale of its anatomical movements. The spider’s action–organization depends on previous organism-environment interactions, and on its modification of environmental structures that stretches well beyond the scale of its present bodily sensitivity to changes in its immediate milieu.

« 32 » Our concern here is that these aspects of organism-environment interactions seem in principle to be beyond the reach of current enactivist accounts. Take, for instance, this statement of the enactive notion of cognition:

> Cognition is the regulated sensorimotor coupling between a cognitive agent [i.e., an adaptive autonomous system] and its environment, where the regulation is aimed at aspects of the coupling itself so that it constitutes an emergent autonomous organization in the domains of internal and relational dynamics, without destroying in the process the agency of that agent (though the latter’s scope can be augmented or reduced).^{44} (Froese & Di Paolo 2011: 18)

« 33 » In that paper, cognitive agents are defined as autonomous systems that adaptively regulate their couplings to their environment via neural sensorimotor activity. In the previous section, we suggested that animals with nervous systems are probably never operationally closed, and so are not autonomous systems; here, we wish to add that the dynamics and the phenomenal experience of organism-environment coupling cannot be accounted for in terms of normativity that arises from self-organization on the scales of bodily movement and physiological processes.^{11} This is both because agency involves multi-scalar organization of activity and because the control of activity tends to be widely distributed across bodily and non-bodily processes.

« 34 » The difficulties are clear when we consider an ant navigating by following a scent trail (Gordon 2010). The ant’s body is responsible for fixing the dynamics of its stepping behavior as a form of coupling to the surfaces in its environment, but it can only be said to be carrying out action–perception cycles with respect to “goals” – that is, norms – specified by the prior environment-structuring activity of other ants. The ant is moving towards a food source, not engaging in undirected taxis or in mere line-following. It undertakes this action by allowing its small-scale activity to be constrained by the scent trail, which is a slow-changing physical pattern created by conspecifics in order to enable this particular large-scale (nest-to-food) pattern of movement. The ant’s activity is thus guided by a norm of food-finding whose instantiation is literally distributed across many members of the ant colony, the food source itself, and the scent trail.

« 35 » Or consider norms of attending a classroom environment. Like the ants, teachers make use of built spaces by facing chairs and tables in a common direction and placing displays at eye height in the middle of the wall. They also rely on habits (e.g., hand-raising) and practices (e.g., note-taking) that allow students to participate in classroom events without disrupting the dynamics of the many-to-one focus on the front of the room. There is clearly normativity here – there is a physical constraint on the activity of the agents in the room – but it does not arise as a consequence of the operational closure of any specifiable autonomous system. There is no system whose integrity or viability depends on the maintenance of group attention, but this is precisely what the norm calls for, and it is deviations from this to which agents in the room are sensitive. Contrary to enactive accounts of the nature of normative action (e.g., Barandiaran & Egbert 2014), activity is regulated and organized according

As claims about coupling on these scales, and so this is meant as a general claim about enactivism. See Steiner and Stewart (2009) for a similar worry.  

11 | We take it that enactivist definitions of autonomy, adaptivity, etc. can only be understood because agency involves multi-scalar organization of activity and because the control of activity tends to be widely distributed across bodily and non-bodily processes.

^44 Cognition is the regulated sensorimotor coupling between a cognitive agent [i.e., an adaptive autonomous system] and its environment, where the regulation is aimed at aspects of the coupling itself so that it constitutes an emergent autonomous organization in the domains of internal and relational dynamics, without destroying in the process the agency of that agent (though the latter’s scope can be augmented or reduced).

^11 We take it that enactivist definitions of autonomy, adaptivity, etc. can only be understood because agency involves multi-scalar organization of activity and because the control of activity tends to be widely distributed across bodily and non-bodily processes.
to historical norms, a situation that cannot be readily analyzed using any available naturalistic terminology. The important thing to note here is that if we restrict ourselves to the conceptual apparatus of enactivism, we are unable to clearly state what happens when a teacher helps a student calm down, states a fact, or guides a student through the method for solving a problem. Nor can we differentiate these events from one another or link their occurrence or dynamics to particular mechanisms and processes.

« 36 » We ought not to be surprised by this mismatch between situated action and the enactive framework for understanding it. Sense-making and intrinsic normativity must be understood as part of an effort to provide general dynamic-systems-theoretic explanations for very broad classes of phenomena. Along with “adaptive autonomy,” “sense-making” is intended to specify the formal, systems-theoretic characteristics of agency as a general property. Their inadequacy in accounting for actual biological organization comes from the fact that the strategies living systems use for intentionally organizing relations with their environments turn out to be hugely variable over time and between individuals. We strongly suspect that there are no systems-theoretic characteristics common to the ecological niches of all lineages of organisms, but at the very least, if there is a universally applicable logic to organism-environment relations, it is not the logic of sense-making and intrinsically produced norms. This is our second disagreement with enactivism.

Interactivity

« 37 » Our own approach fits into the conceptual space opened up by the foregoing negative comments. It begins with our Maturana-derived view of living systems as self-sustaining but operationally open, and as realizing their molecular self-creation in a wide variety of ways, which constitutively involve environmental structures, con-specifics, other lineages of organisms, and routines, habits, and other ways of stabilizing activity. More precisely, we assume that lineages and individual organisms are constituted by the way they interact with the environment. The same assumption applies to intentionally organized activity – this, too, is constituted interactively. That is, not all living systems display the characteristics of Varelian autonomy, and intrinsic teleology (as enactivists conceptualize it) is not always the basis of how organisms make sense of the world. Our approach, based as it is on interactivity and on related concepts such as distributed cognition, is an attempt to come to conceptual and methodological grips with the consequences of these assumptions.

Human interactivity

« 38 » “Interactivity” has always been used, thus far, to pick out social, cultural, and technological influences on the dynamics of human activity. Steffensen (2013) offers a more concrete definition: interactivity is human activity that is so organized. Specifically, interactivity is “sense-saturated coordination that contributes to human action(s),” which can be cashed out as follows.

« 39 » “Coordination” is coupling on the timescales of a body’s molecular processes, movement of its anatomy, and perhaps other closely connected scales defined by a person’s own modes of self-organizing (Cowley & Steffensen 2015). For instance, N. J. Enfield (2013, 2014) describes conversation as playing out on an “enchronic” timescale, which is “grounded in trajectories of co-relevant actions” (Enfield 2011: 287) rather than in any strictly temporal unit.

« 40 » “Sense-saturation” indicates several things at once. First, it indicates that coordination is experientially and emotionally rich, and that both of these aspects are fundamental to how human activity is organized. Second, it indicates how human activity is constrained and sometimes constituted by the practices and social roles, techniques and tools, articulatory gestures and other patterns of vocal activity, ways of seeing pictures and other aesthetic objects, concepts, and many related phenomena that make up the cultural ecology in which humans act (Hutchins 2014; Steffensen & Fill 2014; Steffensen & Pedersen 2014; Uryu, Steffensen & Kramsch 2013).

« 41 » “Actions” are directed changes in human-environment systems, where “directedness” is a matter of emergent functions serving to temporarily organize (“soft assemble”) multiple heterogeneous components of a person-environment system (Kello & Van Orden 2009; cf. Bingham 1988; Wilson & Golonka 2013). This view of directedness is similar to Scott Kelso’s (1995: 137–149) description of intentionality as constraints on one or more of the order parameters characterizing a system’s trajectory of change at a given moment. Consequently, it is analogous to – but far more substrate-heterogeneous than – the enactive notion of intrinsic normativity. Because human action is usually co-action with other humans, and because it is constituted on multiple timescales at once, the intentionality that “directs” a movement as it begins will be only one of the many regulatory influences that constrain the agent-environment system as the movement plays out.

« 42 » Some of the consequences of such a view can be drawn out with an example from an experiment on problem-solving, borrowed from Steffensen, Vallée-Tourangeau and Vallée-Tourangeau (2015; see also Cowley & Nash 2013; Kirsh 2015; Steffensen 2015). Participants were asked to sort 17 small animal figures into four “holding pens,” which they were to make out of pipe cleaners, in such a way that there were an odd number of animals in each pen. This is known as an “insight problem,” because it requires the subject to change an assumption implied, but not stated, by the way the problem is posed. In this case they have to realize that the four pens can overlap, allowing an animal to be in two pens at once (if the pens are kept separate, the problem is impossible). One participant in particular displayed an interesting pattern of behavior: she became stymied by the evident impossibility of the problem, and, after a pause, began straightening out her pipe cleaner pens, making them into rounder, more perfect circles. As she did so, the pipe cleaners in her hand caught on the pipe cleaners of the pen sitting on the table nearby, dragging it along with her hand movements so that it was partly underneath the one she was holding. When she finished re-shaping it, she set that pen down partly on top of the lower one, and, when she reached out to separate them, she suddenly stopped, brought her hand back to her face, and instead reached out to make the final two pens overlap as well. She went on to solve the problem using overlapping pens.
activity that emphasizes a particular set of research interests. In what follows, we will develop both of these aspects of the idea.

« 46 » It is helpful to begin with expert tool use as an illustrative example. This relies on a particular form of bodily and attentional expertise wherein the tool-user attentionally selects specific parameters of the coupled system consisting of their body, the tool, the material, and the environment, and then closely monitors and regulates these parameters as the activity plays out (Baber 2015; Baber, Parekh & Cengiz 2014). The skill consists of an ability to use lived experience to manage the coupling of one’s body to a material in the environment by means of a tool, and in service of aesthetic and conceptual goals (cf. Malafouris 2015). This is difficult to conceptualize in enactivist terms, but easy to conceptualize in terms of interactivity. We need only point out that the process of enskillment is not in the manner of a one-and-done event (or a series of such), but is instead a lifelong pattern of body-tool-material encounters, which are connected into a coherent long-term pattern by the experience and bodily organization of the tool-user.

« 47 » Interactivity is the idea that action by biological agents is always fundamentally heteroscalar (i.e., its dynamics are regulated by processes on several different timescales) and so is strictly non-localizable in space and time (Steffensen 2015; Steffensen & Cowley 2010). That is, organisms are constituted by processes that play out on multiple timescales, and it follows that their actions are organized on multiple timescales as well. If we assume actions are trajectories in some actual spatiotemporal possibility space, then their beginnings, ends, and so on are determined on the appropriate timescale (e.g., the timescale of bodily movement, or of a cascade of neurophysiological processes, or of an experienced event). However, in order to explain, say, why an organism undertook one action rather than another, or when an action functions as an instance of a phenomenal type, we need to ask how the action is organized by (i.e., both constituted and enabled/constrained by) patterns, events, and processes relevant to the organism that are concurrent but exist on different timescales (Lemke 2000; Steffensen & Pedersen 2014). We refer to patterns, events, and processes of this kind as “non-local resources,” by which we mean that they are explanatory resources needed to account for non-localizable actions.

« 48 » This leaves us with several basic conceptual tools. In addition to non-local resources, we have interactivity itself, which is the bringing-together of non-local resources with small-scale bodily dynamics in the course of non-localizable (inter-)action that they constrain and constitute. In relation to these concepts, “agency” gives a name to the many various and heterogeneous ways in which organisms achieve this integration of regulative influence and constitutive processes into their activity. There is no consistent, general logic to agency across species, as each lineage will manage their ecological niches in their own ways. These will range from massively heteroscalar in the human case to monoscalar (or close enough as makes no matter) for some bacteria12 (Johannessen & Steffensen, forthcoming). An important caveat here is that for humans, interactivity always depends on lived experience (including attention and emotion). Other lineages of organisms manage the complexity and non-linearity of their environmental interactions differently, and whether non-locality and interactivity are useful tools for their analysis is a topic for another paper.

« 49 » Consider the difference between speech and the flocking of birds. Speech (as opposed to non-speech vocalization) depends on at least two types of non-local resources. The first are population-level statistical patterns of sound units, such as prosodic units and familiar phrases (see e.g., Port 2010a; Ramsay & Port 2016). The second are articulatory gestures (Fowler 2014; Goldstein & Fowler 2003), highly regularized synergies among the various components of the articulatory tract whose repetition results in auditorily, visually, kinesthetically, and acoustically similar events. Both types of resources function normatively in that adult humans regulate their micro-scale vocalizations to match the appropriate patterns and instantiate the appropriate synergies. They achieve this by means of rich phonological memory, entrenchment, sensitization, and related mechanisms, all of which implicate

12 “Extended metabolism” by Johannessen & Steffensen (forthcoming).
Cognitive Science Concepts in Enactivism

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For these and innumerable many other examples of interactivity, the mechanisms that underlie them are only beginning to be understood. Our goal here has not been to lay out a well-developed framework for their analysis, but rather to show that an approach based on interactivity is a potentially fruitful way of guiding investigation.

50 Many other non-local resources are ubiquitous in cultural ecosystems. Some of these belong to a general category of highly regularized behavioral patterns that are learned socially, whose function as non-local resources is to enable individuals to regulate their inter-bodily coupling in accordance with specific norms. This category includes rituals, ways of displaying and publicly feeling emotions (Fischer & Mansted 2008; Griffiths & Scartantino 2005; Jensen 2014; cf. Froese & Fuchs 2012: 213f), and techniques for producing and using artifacts (including tools), built spaces, and other slow-changing material structures. Agency with respect to these behavioral patterns— that is, the ability to engage with them as non-local resources— consists of developing bodily expertise guided by highly skillful attending, both of which are often developed by means of having one’s activity closely monitored and guided by older conspecifics (Hoppitt & Laland 2013; Malafouris 2013; Sterelny 2012).

51 For these and innumerably many other examples of interactivity, the mechanisms that underlie them are only beginning to be understood. Our goal here has not been to lay out a well-developed framework for their analysis, but rather to show that an approach based on interactivity is a potentially fruitful way of guiding investigation.
Open Peer Commentaries

on Matthew Harvey et al.’s “Interactivity and Enaction in Human Cognition”

Enaction, and Its Relation to Science in an Objective Key

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> Upshot • Enaction, as a paradigm, is still negotiating its position with respect to science done in an objective key. Some of the problems identified by the authors arise by treating enactive descriptions as if they were realist accounts. Negotiating a resolution here will demand progress all round.

Conclusion • The relation between interactivity and enaction is a positive one. The approaches agree to some extent about research interests and methods, and share certain core notions. Interactivity-based approaches assume that all organisms are autopoietic, but make no claims about the scales on which they realize autonomy, or the synchronic operational means by which they carry it out. In fact, the scales on which a lineage of organisms realizes their autopoiesis is fundamental to their self-definition as a form of life. At least some organisms are constitutively open in their manner of living, such that processes outside their organizational bounds are frequent, repeatedly, reliably, and fundamentally part of how the organisms regulate their activity and engage with the world. Many such organisms are metabolically open (i.e., not literally organizationally closed), but even if they are not, their agency is not accurately characterized by the model of adaptive autonomy, and their sense-making is fundamentally a matter of how their activity is embedded in multiscale processes, patterns, and events that structure their interactions with the world in experientially specific ways.

For the sake of clarity, throughout this article we have been at pains to emphasize what we disagree with in the enactive approach. It bears repeating that we are deeply sympathetic to many varieties of enactivism, core varieties included. If we have a complaint about enactivism, it is this: it seems simply to assume operational closure rather than demonstrating it (e.g., in multicellular organisms), and also to assume – again without reference to observation-based evidence – that the logic of operational closure is the basis for the organization of activity as it actually plays out, despite the difficulty that both of these assumptions seem to contradict the basic biological facts. While autopoiesis is an abstract conceptual reconstruction of molecular self-maintenance, and so evidence-based in that particular sense, the subsequent notions of autonomy and sense-making are not (as indicated by, e.g., Di Paolo 2009a, 2009b). Beyond that specific criticism, this essay has tried to show that any phenomenon that is amenable to enactivist explanations is also amenable to explanation using interactivity and associated concepts, where the difference between the two is largely that the latter seeks to explain activity by means of specific non-local resources and mechanisms by which organisms dynamically engage with them, rather than by facts about a-temporal organization. Aside from these differences, enactive and interactivity-based accounts will be closely aligned, and it is our hope that cross-talk between them will become easier as interactivity-based approaches are applied in greater detail to questions of mechanism, and as enactive approaches are applied to cultural phenomena.

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I suspect to accommodate many of the concerns that Matthew Harvey, Rasmus Gahrn-Andersen, and Sune Steffensen (hereafter, HGS) present in the target article. But the issues of the spatio-temporal distribution of the dynamics of sense-making highlight an important and unresolved issue. HGS contend that enaction describes agent-environment relations as “in-the-moment coupling” ($2$), whereas the activity of humans speaks instead of the integration of heterogeneous resources in organizing their activity ($44$). Agen
tive activity is non-local in space and time ($47$), and so cannot be accommodated within an account of agents as operationally closed, and hence localisable in space and time. This seems to HGS to preclude any adequate account of the ecological transformation that languaging and human sociality bring about ($2$).

It is surely uncontroversial to assert that human activity must be understood in many different ways, and any given activity may demand acknowledgement of processes at diverse temporal and spatial scales. This is the case, not only for generic “languaging,” but for all activity mediated by texts, electronic media, distributed social institutions, and the countless accretions of technologically enabled, coordinated human living. Is this grounds for adopting a completely different approach to agency, treating it as necessarily distributed, rather than a property of a specific form of self-generating and self-sustaining autonomous organisation? I suspect not, but the reason is rather important, and my response is not to reject such a
Cognitive Science Concepts in Enactivism

Concerned only with individuated discrete organisms, but the metaphysical commitments of enaction lie elsewhere.

To draw the distinction most clearly, it will help to contrast the manner in which creation is treated in Buddhist and in Christian cosmologies. Within the Western intellectual tradition, Christianity has been the unacknowledged background against which all the major moves in philosophy of mind and the development of physical cosmology have played out. These have come to adopt a view of time as linear, extending from a single moment of creation (or the singularity antecedent to the big bang, which, being a singularity, cannot itself be considered an event or a moment), and connecting one second to the next. All being is tied to this linear progression, and it is within this mind-independent linear series that life evolved, and that we all progress together from past to future. "Lived experience," to which HGs repeatedly appeal as a basis for knowledge, is something that either exists, or not, within this framework, as this framework aspires to treat of all that exists. This view of time has gone into the literature as John Ellis McTaggart's B-series, or linear time (McTaggart 1908). But such a universe, as understood within an objective key, is mindless. This is the Copernican-Galilean-Newtonian-Cartesian world view tacitly accepted by most researchers, and it has no place for mind (hence the "hard problem" that arises if we adopt that framework). In an objective key, the world comes first, and experience is a puzzle to be understood as something within the world (though never found). Appeals to "lived experience" will thus run into opposition if they feature in scientific discourse conducted in an objective key.

The 1991 text, *The Embodied Mind*, sought to inject some Buddhist sensibility into discussion of mind and experience. Within a Buddhist framework, subject and world arise together. Varela often used the phrase "bringing forth a world" to capture this perspective, and it is linked to the core concept of dependent origination (pratityasamutpada). On this view, experience is not something found in the world; it is the ground from which both subject and world arise in the always-present now. This is roughly aligned with McTaggart's A-series, or lived time, from a phenomenological point of view (especially Heidegger). Contrary to popular opinion, it seems to me that there is no mapping from the A-series to the B-series, or, to put it in contemporary psychological terms, there is no unification possible of the subjective experience of time as flowing (Heraclitian) and the objectivist picture of linear time (Parmenidean). In a strongly constructivist, enactive key, experience is prior to any distinction between subject and world. It is thus the world that needs to be topocalised, not "lived experience."

That these two radically different ontological positions are being confused is clear when HGs speak of an organism's experience as "being coupled to the world" (§13, emphasis mine). If subject and world co-arise, then the "world" of which we speak is not something from the B-series, something that exists in insolent opposition to the subject. It is rather the milieu, or with some degree of caution, we might use the term umwelt. It is "a" world, arising as complement to "a" subject, and at this point we are clearly being tripped up by language that oscillates wildly between different sets of ontological commitments (or between matters of "organization" and matters of "operation," to align this with the vocabulary of HGs). This is nobody's fault. Our language is not separable from the worldviews of language users, and the objective key has had a near-monopoly within the realm of scientific discourse.

The enactive vocabulary has two main concepts for dealing with the historical antecedents that condition the present, and with the apparent problem of discrete individual Cartesian minds. These are structural coupling and participatory sense-making, respectively. The former is a formal means by which the constitution of a given system (and hence also its umwelt) can be tied to its historical trajectory and legacy of past interactions (for organisms, this accommodates both phylogenesis and ontogenesis). The latter provides a way to acknowledge how the sense-making activities of all life forms give rise to different kinds of mutual dynamic entanglement, and hence to the arising of largely shared perspectives, largely shared worlds. These concepts are still works in the making, and the distinction they exhibit with respect to the treatment of time is a pointer to the linguistic tangles we face as this account matures. They probably need extension if they are to serve in some of the discussions HGs wish to have.

Enaction will continue to have a contested relation to the practice of science in an objective key. Too small an intellectual tradition to influence most scientific practice, it does offer a theatre in which the negotiation of conflicting perspectives can be conducted. It opens a door to the negotiation of consensus-based accounts when conflicting value systems are in play, and when consideration of more than one locus of agency is necessary. This is, and will remain, a form of description that will occasion self-reification, that will necessitate an awareness of the framing assumptions of the observer/discussants, and that leads to claims of bounded applicability. It also allows discussion of many kinds of subjects, and many kinds of agency (Cummins 2013). To restrict the accounts of enaction to discrete organisms alone would be unfortunate. The strengths of the enactive approach, I suspect, lie precisely in its flexibility in accommodating agency at many different levels, treating subjectivities that are collective, transient, ad hoc, as well as those rooted in individual organisms (or human bodies). It is well positioned to contribute to pluralist ontologies (Latour 2013), and this capacity will only become more important as our discourse extends to meet the demands of a biosphere in crisis, a non-unified species of language users, and the inevitable collision of science with political and religious concerns.

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Interactivity Should Aim to Extend, Not Reject, the Conceptual Foundations of Enaction

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> Upshot • Enaction is a diverse research program and some of its texts can be interpreted in terms of a critical contrast to interactivity. Yet much of the former has already started to move in a direction favored by the latter: toward systematic studies of how human activity is shaped by social, cultural, and technological influences. Interactivity could therefore help enaction to provide a better account of such highly mediated and augmented forms of sense-making.

« 1 » According to Matthew Harvey, Rasmus Gahrn-Andersen and Sune Stefansen, the relationship between interactivity and enaction is a “positive one” (§52), with sufficient potential for increased alignment such that they conclude their target article by expressing hope for easier cross-talk (§53). Yet at the same time, they are at pains to highlight shortcomings of the enactive approach, which to them place in-principle limitations on its applicability to the kind of phenomena that interactivity has been most interested in describing in detail, namely the way in which the dynamics of human activity are shaped by social, cultural, and technological influences (§38).

« 2 » Indeed, it is no secret that the enactive approach has long been faced with the challenge of overcoming a cognitive gap, i.e., the problem of how to extend its conceptual framework from basic organismic minds to specifically human forms of cognition and action (Froese & Di Paolo 2009), and the target article resonates with this critical self-assessment. On the other hand, in recent years there have been an increasing number of applications to precisely these phenomena. This is not the place to review these studies in detail; I will just highlight that they include one of interactivity’s favorite topics: languaging (e.g., Cuffari 2014).

Thus, it is unclear if there are genuine differences between these approaches, or if they can rather be taken as complementary.

« 3 » 1 agree with Harvey et al’s conclusion that the latter is more likely the case. For example, interactivity is good at producing detailed studies of specifically human activity, which result in descriptions of phenomena that can be suitable targets for developing the basic explanatory concepts of enaction. Yet this possibility for future collaboration is obscured by misunderstandings and an overly restrictive interpretation of the enactive approach, which I aim to help clear up with this commentary. I hope to show that there is nothing about its conceptual foundations that stands in contradiction to interactivity. Neither are they set in stone, and interactivity is welcome to extend them as might be required for accounting for specialized kinds of human activity.

« 4 » Harvey et al. introduce the key concepts of the enactive approach by contrasting it with Humberto Maturana’s biology of cognition. This is indeed a useful strategy because the former is in significant ways derived from the latter, but unfortunately they portray the development of ideas the other way around. They attribute to Maturana the position that “circular molecular organization might, without contradiction, be realized operationally by non-circular, constitutively open and environment-involving, massively distributed and multi-scalar processes” ($17$). To be fair, Maturana’s writings are notoriously difficult to understand and his theory has subtly changed over the decades, and therefore lends itself to conflicting interpretations. However, on this point, Harvey et al. appear to be mistaken. To see why, we only need to recall Maturana’s so-called doctrine of non-intersecting phenomenal domains. It is worth quoting him at length since this will help to clear up several issues:

**Autopoiesis describes the internal dynamics that constitutes a living system as a living system in the molecular domain, but a living system also exists as a totality in a relational space where it operates as an organism. The constitution of living systems as autopoietic systems entails their constitution as organisms as a result of the constitution of their operational boundaries which separate the molecules that dynamically participate in their autopoiesis from those that do not. So, living systems exist in two non-intersecting domains, the domain of their components as molecular autopoietic systems, and in the domain in which they operate as organisms (totalities) in a medium that makes them possible. These two domains do not intersect, the processes that take place in one cannot be reduced to the processes that take place in the other. Yet, these two phenomenal domains modulate each other through the structural changes that take place.** (Maturana 2002: 14f)

« 5 » We can see why Harvey et al’s example of “eating and breathing are ways of maintaining organizational closure on the molecular level” ($17$) is not compatible with Maturana’s theory of autopoiesis. First, eating and breathing are behaviors that take place in the relational domain of the organism and its medium, and as such they cannot be taken as constitutive of the organism’s molecular processes, given that these two non-intersecting domains are only permitted to modulate each other. Second, contrary to their interpretation that Maturana’s work “makes no particular claims about the operational dynamics of living systems” ($17$), there are strict requirements. For example, these dynamics are molecular, they constitute an operational boundary in that domain, and they are internal to that boundary. Eating and breathing satisfy none of these requirements.

« 6 » If this is on the right track, then on Maturana’s view, eating and breathing are behaviors that are correlated with the constitutive (molecular) dynamics of the living system, and they can even mediate each other. But their interdependence is fundamentally restricted: the only thing we can say is that they just happen to be correlated in this way because of a history of natural and ontogenetic structural drift, and because otherwise the autopoietic system in the molecular domain would not have persisted. Eating and breathing happen to enable an organism’s continued survival, but their realization is not part of its identity as the kind of being it is. In other words, if even eating and breathing — behaviors that are necessary for the very survival of the animal — cannot be meaningfully incorporated into its constitutive dynamics, then this aim becomes simply inconceivable for the higher-level behaviors that interactivity is most
interested in, for example a teacher maintaining group attention in the classroom (§35). Here I am assuming that interactivity is interested in explaining such activity in a more satisfying way than by pointing to the contingent conservation of adaptation of the organisms participating in it.

Autoepoietic enactivism can be seen as an attempt to overcome these limitations in a gradual and systematic manner. Most importantly, it preserves the claim that an autopoietic system can be described from the perspective of two distinct and mutually irreducible domains, i.e., component processes and interactive processes, but rejects the doctrine of non-intersection. This move, taken together with Francisco Varela’s redefinition of autonomy as a form of autopoietic self-production that is domain general,1 opens up the possibility for distributed and environment-involving behaviors to play a constitutive role in maintaining organizational closure on the molecular level.

Furthermore, behaviors are no longer seen as nothing but contingent outcomes of a system’s conservation of adaptation and organization, like a sailing boat whose drifting is passively determined by a combination of its physical structure and the prevailing winds (see Maturana’s 1988 concept of ontogenetic structural drift). The concept of an active process of regulation of agent–environment coupling, for example expressed in terms of adaptivity (Di Paolo 2005, 2009a), is what enables us to conceive of behaviors as organized according to norms in the first place – an idea that has no place in Maturana’s anti-teleological framework (see Villalobos and Ward, this issue). The upshot of these conceptual changes is that the enactive approach is in a position to address precisely the kind of phenomena in- teraction dynamics that incorporate normatively organized behaviors that are distributed and environment-involving, and that can serve as a bridge from life to society (e.g., Di Paolo 2009b).

Some illustrative examples may help. First, certain behaviors can now be seen as directly playing a constitutive role in the maintenance of organizational closure. For example, movement can enable a self-producing chemical network to persist in concentration ranges that would otherwise cause it to disintegrate (Froese, Virgo & Ikegami 2014). Second, the chemical processes of autopoiesis no longer need to be seen as only internal to an organism’s body. For instance, when a worm excretes a sticky substance into its tunnel and thereby externalizes a part of its digestive process, we should take the worm’s constitutive chemical dynamics to be distributed across the body–environment system (Virgo, Egbert & Froese 2011), forming what we might call an extended metabolism. Third, the distributed constitutive dynamics can also be environment-involving. For example, Ezequiel Di Paolo (2009a) has appealed to the fact that several species of insects are able to breathe underwater by trapping air bubbles in their hairs, mediating the regulation of environmental coupling via the incorporation of an external resource, and thereby bringing forth a more subaquatic way of life.

These examples should go some way toward addressing the concern expressed by Harvey et al. that non-bodily aspects of organism-environment interactions seem in principle to be beyond the reach of current enactivist accounts (§32). But can enaction also account for the other-related normativity of social interactions? Harvey et al. are skeptical and cite Froese and Di Paolo’s (2011) definition of cognition in support of this concern (§§32f). However, they neglect to mention that we emphasized that the domain of cognition should be thought of in terms of a hierarchical decoupling from the metabolic domain, thereby permitting cognitive processes to be organized by non-metabolic norms. Once it has been shown how non-metabolically mediated regulation of coupling can be a part of the constitutive dynamics of the organism, for example in terms of recurrent neural sensorimotor activity and habits, nothing stands in the way of addressing phenomena whose forms of mediation are increasingly distant from the spatiotemporal scales of an individual’s biological embodiment, i.e., what Harvey et al. refer to as non-local resources.

Indeed, one of the most exciting contributions of the enactive approach in the last decade has been its investigation of how interactions among individuals can determine their behavior and their organization, which has resulted in the rejection of one of the essential premises of traditional cognitive science, namely methodological individualism. For example, when two or more individuals are co-regulating their interaction dynamics, and thereby their sense-making activity, they can be said to be shaping each other’s experience, as captured by the concept of participatory sense-making (De Jaegher & Di Paolo 2007). This interaction process can become self-sustaining, as each action tends to evoke a re-action, and we thus have a case of Varela’s generalized concept of autonomy in the domain of social interactions. It permits us to study individual behaviors and social interaction dynamics in terms of two interdependent yet mutually irreducible domains.

The concepts of participatory sense-making and the autonomy of the interaction process have been criticized by proponents of interactivity, who claim that these concepts are insufficient for accounting for most human social activity because (a) they neglect the role of the impersonal resources of culture, and (b) they fail to appreciate the role of lived experience in development (Cowley & Gahrn-Andersen 2015). It is not clear to what extent Harvey and colleagues share the second concern; they recognize that first-person experience has been one of the cornerstones of enaction since the beginning (§6). Certainly, development and phenomenology of sociality have not been neglected topics (Fuchs 2013). However, Harvey and colleagues agree with the first concern, which amounts to the claim that the enactive approach is incapable of addressing the role of non-local sociocultural resources because it relies on the concept of operational closure, both at the level of the individual and of the interaction process.

I hope to have shown that this worry is misplaced. It is precisely the extension of Varela’s generalized concept of

1 As part of the extension from autopoiesis to a domain-general concept of autonomy, Varela (1979) introduces the term organization closure. Confusingly, Harvey et al. attribute this concept to Maturana’s autopoietic theory, although he has never used this term, while limiting Varela’s theory to operational closure (§19). It would be good if Harvey et al. gave clear definitions of these terms, as they put a lot of weight on their being different although many scholars use them inconsistently or even interchangeably.
autonomy to the social domain that permits us to develop an account of the influence of heteronomous sociocultural processes on human activity because it prevents any attempt at reducing these processes to the actions of the individuals that constitute them at any one point in time (Torrance & Froese 2011). In other words, the autonomy of the social world is a necessary condition for claiming that its interaction processes are genuine and have an effect on our lives, and yet they operate on timescales that go beyond individual actions, and in some cases beyond our lifetimes.

- To be fair, it might at times sound as if the enactive approach is locked into sub-personal explanations of the here-and-now. But this legacy of Maturana’s biology of cognition, which also emphasizes that the behavior of organisms must be understood on the basis of their being state-determined systems, is simply a way of forcing us to distinguish functional from operational explanations. For example, when we want to explain why an organism undertook one action rather than another ($47), we can appeal to non-local resources, for example the historical norms instituted by the legal system. But this does not suffice as an explanation of how, in that very moment, the operations underlying the individual’s choice of action were realized in accordance with those cultural norms. The challenge is to provide an account of how such non-local resources shape local human activity, and it seems to me that the enactive approach is well positioned to do so (Gallagher 2013).

- On this view, phenomenology, intersubjectivity, and the products of culture must be analyzed in an interdependent manner (Havelange 2010). It is precisely in this interdisciplinary study of human cognition that interactivity could offer much needed help to enaction, while interactivity could benefit from extending, rather than rejecting, enaction’s key explanatory concepts.

- For instance, Harvey et al. do have a point that the currently most popular account of sense-making, which tries to ground all forms of meaning in terms of perturbations to the different kinds of viability associated with an organism’s way of life, seems too limited to account for all facets of our lived experience. To return to an earlier example, what kinds of viabilities are perturbed during the teacher’s task of regulating attention in the classroom? Enaction and interactivity may have to work together to find another way of accounting for such abstract normative organization of behaviour, one that is hierarchically decoupled from an agent’s basic need to regulate its responses so as to directly mitigate threats against the integrity of its way of life.

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What Is at Stake in the Disagreement Between Interactivity and Enaction?

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> Upshot • To sort out their differences with enactive theory, interactivity theorists would do better to focus on operational closure only insofar as it constitutes a condition of intrinsic normativity or self-regulated coupling.

- The target article presents a comparison of two constructivist perspectives in cognitive science – the newly emerging interactivity-based approach and the increasingly influential enactive theory (especially the post-Varela branch) – with the dual purpose of articulating the theoretical advantages of the former while highlighting, in contradistinction, certain critical limitations of the latter. In my estimation, Matthew Isaac Harvey, Rasmus Gahrn-Andersen and Sune Vork Steffensen succeed in presenting interactivity as a distinctive viewpoint that promises new insights into the nature of cognition, but the central concept of “non-local resources” remains unclear.

- Also, and for related reasons, it remains unclear whether their criticism of enactive theory hits its mark. I have doubts about the accuracy of some of the authors’ claims about enactive theory, but more importantly I do not believe that they have shown that the critical issue of operational closure bears directly upon the core explanatory concepts of post-Varela enactive theory, especially its understanding of cognitive agency as a normatively self-regulated process of structural coupling. Even if operational closure has been wrongly assumed by enactivists after Francisco Varela, it is questionable whether post-Varela enactive theory has much at stake in this assumption. If operational openness can be granted by enactivists (and perhaps it already is), then the authors’ argument loses much of its critical leverage, and it becomes difficult to assess their claim that interactivity offers a substantively different theoretical basis for “4E cognitive science.”

- In hopes of pinpointing the crux of the authors’ disagreement with enactive theory, I will attempt here to summarize what I see as the key points of their argument. Like the authors, I am sympathetic to many aspects of enactive theory but I also find the post-Varela notion of “sense-making” to be highly problematic, albeit for different reasons (Barrett 2015a, 2015b). Accordingly, my intent is not simply to defend enactive theory against criticism but rather to contribute to the authors’ project of mutual clarification.

> To begin, the interactivity approach is distinguished by its starting point: it starts with human social interaction and linguaging and seeks to apply insights gained from this context to the construction of more general theories and models of cognition. It therefore shares with enactive theory a radical thesis about contingency of mind, i.e., that the “higher” forms of human cognition share basic traits with the agency of primitive organisms. Mainstream “cognitivist” cognitive science also frequently assumes language as the paradigmatic form of cognition but usually understands language in rule-based, representational terms. In contrast, the interactivity approach asserts that language can be understood in fully nonrepresentational terms, where representations are under-
stood as content-bearing states or structures ($\S 12$).

« 5 » If we take up an interactivity-based approach, the authors suggest, we are more readily able to realize the importance of heteroscalar dynamics and distributed features — what they call “non-local resources” — for understanding cognitive agency of all kinds. They also claim that the assumption of operational closure prevents post-Varela enactive theory from accounting for these non-local resources. The concept of non-local resources seems to be both the central insight of the interactivity approach and its greatest expository challenge. In the case of human cognitive agency, the non-local resources par excellence are “social, cultural, and technological influences” ($\S 38$). These influences evidently entail norms of a historical and distributed nature such that they lie outside the “immediate spatiotemporal scope” ($\S 3$) of a particular human action. It should be noted that this non-local nature is not just a problem for enactive theory; according to the authors, such influences “cannot be readily analyzed using any available naturalistic terminology” ($\S 35$). Be that as it may, while social, cultural and technological influences on human interactivity serve as paradigmatic examples of non-local resources, the authors wish to show that non-local resources are widespread features of cognitive agency (as demonstrated by such examples as spiders + webs and ants + scent trails).

« 6 » It is difficult to tell whether the concept of non-local resources offers us a new advance in understanding or simply a re-description of features that are already (more or less) understood in different terms. Among the things that would seem to count as non-local resources are habits and affordances, both of which present challenges to some explanatory frameworks but certainly not to all (for enactive work related to these concepts see, e.g., Barandiaran & Di Paolo 2014; Buhrmann, Di Paolo & Barandiaran 2013). At a more general level, the acceptance of non-locality seems to require acknowledgement of the relationality and continuity of natural processes. Are features of relationality and continuity actually outside the scope of “any available naturalistic terminology”? Perhaps after David Hume it became commonplace for philosophers to deny these features as part of experience, but good arguments are on hand to show the inconsistency of this denial (e.g., Whitehead 1967), and in any case it is doubtful that scientific explanation has ever been faithful to Hume’s strictures. More to the point, if one accepts relationality and continuity as part of our understanding of natural processes — and I see no reason to believe that enactive theory does not — then how is one to define the “immediate spatiotemporal scope” to which enactive theory is supposedly confined?

« 7 » Here is where I suspect the criticisms of the authors are misplaced. I see no reason to ascribe to enactive theory any sort of commitment to the “immediate spatiotemporal scope” of organism-environment coupling. Yet this seems to be the upshot of the authors’ argument that enactivists wrongly assume operational closure. For instance, they express the key insight of interactivity — the dependence of human cognition on non-local resources — with the claim that human action evidently “cannot be exhaustively explained in terms of the coupling of bodily movement to surfaces of the environment” ($\S 3$). The implication of this statement is that enactive theorists believe that human action can be exhaustively explained in this way, but I see no evidence of this narrow view.

« 8 » Perhaps the authors mean to show that this narrow view of cognition is an unacknowledged consequence of a commitment to operational closure. So let us consider operational closure more carefully. The main point of the authors’ historical critique of enactive theory is to show that after Varela, the concept of autonomy developed by Humberto Maturana shifted from a relatively open notion of organizational closure to the much more restricted notion of operational closure (see $\S 27$). Thus, according to the authors, “Varelian autonomy” and operational closure are roughly synonymous, and the most precise definition of the problem with this identification is that it specifies “the defining properties of the system’s actual operational dependencies over time” (ibid.), and this specification of operational dependencies over time precludes heteroscalar coupling or indirect kinds of dependency. So we are back to the claim that enactive theory confines its description of cognitive agency to a narrow view of organism-environment coupling “in the moment.” Against this view, the authors argue — using several cases of non-human cognitive agency — that the processes that maintain an organism loop through the environment at various timescales and through various indirect kinds of dependency.

« 9 » Based on my reading of post-Varela enactive theory, however, the essence of “Varelian autonomy” is not operational closure per se, but rather the way in which organism-environment coupling is regulated by the organism with respect to its own self-generated norms. What decisively divides post-Varela enactive theory from Maturana, then, is the insistence of the former on the asymmetry of organism-environment coupling (Barandiaran, Di Paolo & Rohde 2009). This asymmetry — based on some kind of homeostatic self-regulatory capacity — is what distinguishes living systems from other kinds of structural coupling and is the hallmark of cognitive agency qua “sense-making” (e.g., Di Paolo 2009a). The authors recognize this notion of “sense-making” as central to post-Varela enactive theory (Section 3.2, §§31–36), but again their critique is steadfastly focused on what they see as the narrowly defined timescale of this self-regulatory capacity. Their insistence on this point seems excessive — again, nowhere do they provide evidence of a commitment to a single timescale of coupling — but let us leave this question open.

« 10 » Here is where I believe the actual crux of the disagreement between interactivity and enactive theory should lie, if indeed there is a serious disagreement to be had. To my mind, the most important question is whether the kind of operational openness insisted upon by the authors — heteroscalar coupling and all the “non-local resources” to which it gives access — is compatible with the self-regulated nature of coupling that defines cognitive agency for post-Varela enactivists. In other words, can organism-environment coupling be both heteroscalar and self-regulated? I do not see why not. But more importantly, are the authors arguing that it cannot? It is not clear.

« 11 » The authors’ main objection to the intrinsic normativity of sense-making is that many of the norms that influence be-
haviour are not intrinsic to the individual organism. But enactivists could acknowledge this point and still insist on intrinsically generated normative regulation as the mark of cognitive agency. That is, it might be possible to have intrinsic normativity without excluding other kinds. In any case, I am suggesting that enactive theory only has a stake in operational closure insofar as it is necessary for self-regulated coupling, and their claim about self-regulated coupling is that it is necessary for cognitive agency – but not that it is exhaustively explanatory of all aspects of all cognitive behaviour.

12 In certain places, the authors do seem to reject intrinsic normativity as a necessary condition for cognitive agency (e.g., §37). But again their position is not sufficiently clear, as they might only mean to say that intrinsic normativity is not enough. In an important passage (§41), they define action in terms of the temporary organization of heterogeneous components of the person-environment in a way that fails to specify – perhaps deliberately – how the task-specific and goal-directed nature of this organization is decided. More tellingly, when speaking of Scott Kelso’s theory of intentionality (ibid.; Kelso 1995), they neglect to specify that intentionality refers not just to any constraint on the order parameters of system trajectory, but rather just those constraints that are self-imposed by the person.

13 Here is a missed opportunity to clarify the crucial distinction between what is necessary for cognitive agency and what is sufficient to explain the actual trajectory of system behaviour. Certainly there are multiple constraints on human action as it plays out, and many of these constraints come from outside the individual – just as the authors say – but what makes an action intentional is not just its original impetus but also the continuing role that the individual plays in the coherent integration of these constraints so that the action remains directed toward a specific task. In the case of intentional action, therefore, not all constraints that arise from the total person-environment system are equal: only those that arise from the person are responsible for the selection of relevant environmental constraints (e.g., affordances) and the integration of these constraints into a coherent, task-specific course of action.

14 A closer look at the authors’ account of human interactivity suggests that they also give the person a privileged role in the normative regulation of behaviour. That is, even while they locate multiple sources of normativity outside the person, the person remains for them a necessary source of the norms that integrate these and other non-local resources into a unified course of action. This is apparent in their description of a problem-solving experiment in which a subject’s “insight” consists in the re-organization of various materials so as to bring different affordances into play. The accidental redistribution of the materials may have triggered the insight, but only the person in her intentional capacity – as directed by a “conceptually-defined motive” (§43) – can realize that the new configuration provides a solution.

15 The authors’ observation that human action consists of the integration of heterogeneous components across multiple timescales seems to me a valuable insight, deserving of careful consideration. Even so, when we ask what decides or governs this integration, I remain convinced that the enactivists are on the right track with their proposal of intrinsic normativity. On the other hand, there may be serious problems with the enactive concept of normativity (Barrett 2015b), and no doubt the interactivity approach has much to contribute to this issue. With respect to the example of the problem-solving situation just discussed, I would say that the weakness of enactive theory is not that it cannot account for the use of distributed resources but that its picture of self-generated normativity cannot account for the switch from one way of organizing interaction to another.

Matthew Isaac Harvey and colleagues, in their target article, present what they consider to be two core concepts of enactivism that are fundamentally flawed, i.e., that (a) (all) organisms are operationally closed, and that (b) “sense-making” depends on engagement with non-local resources. I focus my commentary on sense-making, with particular reference to the notion of homeostasis given by advocates of cybernetic-enactivism, and contrast it with that of allostatics, as defined by Peter Sterling (2004, 2012) and Jay Schulkin (2011a, 2011b). I place focus on the latter notion and discuss it with respect to Harvey et al’s interactivity position.

According to Ezequiel Di Paolo (2005), in Harvey et al’s terminology a post-Varela autopoietic enactivist ($23), the original formulation of autopoiesis (Varela 1979; Maturana & Varela 1980) did not sufficiently explain sense-making. Di Paolo brought in
the notion of adaptivity – “the capacity of the organism to regulate itself with respect to the boundaries of its viability” (Di Paolo 2005: 429) – in order to bridge this perceived gap. The paradigmatic case of such an adaptive, sense-making agent, for the post-Varela autopoietic enactivist perspective, is the homeostat of Ross Ashby (1952) – a cybernetic manifestation of classically conceived biological homeostasis. Simply, adaptivity, in the homeostat, is construed as exploiting a homeostatic process through first- and second-order feedback. First-order feedback is internal – the agent senses whether its essential conditions of self-maintenance (essential variables) are compromised. Second-order feedback concerns random reconfigurations of parameterizations of sensor-motor couplings whose stability is arrived at by “positive” first-order feedback (the agent is in equilibrium). Double order feedback imubes, in this non-autopoietic abstraction of an organism, adaptivity mechanisms of the type that enable sense-making. In a recent publication of Anil Seth (2014), the ultrasprawl property of Ashby’s homeostat was again alluded to. In this case, he described the second-order feedback as “allostatically [re-organizing] a system’s input-output relations when first-order feedback fails” (Seth 2014: 7) and then defines allostatic as “the process of achieving homeostasis,” originally presented in Xiaosi Gu and Thomas FitzGerald (2014). The use of the term allostatic is, thus, of contemporary relevance to cybernetic-enactivists. However, there are many biological exponents of allostatic holding differing definitions. These definitions allude to different bioregulatory effects and have implications for the role of intrinsic-extrinsic norms in sense-making. Using the Ashbyan homeostat (cybernetic-enactivist) analogy, we summarize three homeostaticallostatic regulatory positions for sense-making:

1 | Reactive homeostatic regulation: Sense-making exploits behavioural corrective mechanisms (second-order feedback) whenever homeostatic disequilibrium is signalled (via first-order feedback);

2 | Transient allostatic regulation: Homeostatic disequilibrium is permitted in the face of ongoing behaviour towards extrinsic “goals” or norms. Satisfaction of such norms has the effect of facilitating the intrinsic norm of long-term homeostatic equilibrium. The reactive process (Position 1) is embedded within this allostatic process. Second-order feedback involves behavioural corrective mechanisms but may include transient re-setting (autonomic effects) of first-order homeostatic bounds in order to meet present demand.

3 | Non-transient allostatic regulation: A neurophysiological state depends on extrinsic demands relevant to survival and reproduction in accordance with “goals” and extrinsic norms. Bounds of operation of certain variables are a constraint on, rather than the point of, sense-making. Second-order feedback involves behaviour suited to meet present demand and includes redefinition of first-order homeostatic bounds according to ever-shifting extrinsic demands.

4 | Position 1 is non-autopoietic, and, therefore, not a biological “sense-maker.” With this caveat in mind, I contend that Ashby’s homeostat provides a useful point of reference for discussing adaptive processes integral to sense-making mechanisms.

2 | Seth suggests his particular predictive processing account of cognition is an example of weak enactivism – incorporating the notion of agent-environment coupling through active perception. Seth describes himself as not holding to strong enactivism since he adheres to a framework that uses internal models. He might thus be viewed by Harvey et al. as a post-post Varela autopoietic enactivist.

3 | For extrinsic norms, we might also read interactive norms – the critical point is that the norm is the result of the organism’s perceived mode of coupling it has with its (social) environment.

4 | However, “ideal” homeostatic bounds for battery levels are still imposed upon the robot’s design from without.
for achieving homeostasis (Gu & FitzGerald 2014; Seth 2014). A biological perspective that resonates with the aforementioned is that of John Wingfield (2004). Allostasis, compared to reactive homeostasis, provides greater flexibility of the organism-environment coupled system as a whole and entails “emergency adjustments of physiology and behaviour to maintain homeostasis in the face of challenges” (Wingfield 2004: 312).

6 In the case of Position 3, Sterling (2004, 2012) has advocated that the reactive homeostasis model is wrong. In Sterling’s account, allostatic processes do not subserve homeostatic local states. Also at odds with Position 2, allostatic processes are not merely “emergency systems superimposed on the homeostatic model” (Sterling 2012: 2). The standard medical model of homeostasis, the classically conceived Walter Cannon (1929) model of defending set points (though see Craig 2015), insofar as medical treatments focus on localized symptoms, e.g., drugs to reduce blood pressure, is misguided. Allostasis, here, is viewed as a top-down interactive-constitutive process that recruits resources from many (local) physiological systems to meet predicted current demand. This perceived demand is often extrinsic, e.g., set by social norms, which exerts a pressure, both in terms of survival and reproduction. Sense-making is, thus, constrained, rather than set, by self-maintenance. Moreover, the ideal physiological state for the organism – in terms of self-maintenance – is not static. Sterling uses the example of blood pressure, which fluctuates throughout the day as a consequence of daily rhythms and may be elevated for prolonged periods according to extrinsic demands. One can imagine the human sat at his/her office working long hours to safeguard his/her job being facilitated in this endeavour via elevated blood pressure. Rather than viewing this as the ideal state, or a transient coping mechanism for facilitating long-term homeostasis, any given physiological state may be viewed as an adaptive response to the particular social pressures that occur within an organism-environment coupling, and are themselves subject to change.

7 Sterling’s (2012) discussion of fluctuating blood pressure over cycles of activity and according to changing extrinsic demands is perhaps an example of what Harvey et al., in §31, refer to as “the rhythms that characterize the activity of a given organism or lineage.” The timescale of evaluation of sense-making for the organism should encompass daily (and possibly seasonal) cycles on this model’s account (compare to Harvey et al.’s multiple timescale view of sense-making in §47). For Sterling (2012), a healthy system should be defined as one of “optimal predictive fluctuation” (Sterling 2012: 9) and inflexibility of essential variables regarding their range of operation should be met with therapeutic measures designed to restore flexibility of the response, e.g., that influence the perception of meeting extrinsic demands.

8 From a cybernetics-enactivist perspective, the set boundaries of the ideal homeostatic range that provide the metric for first-order feedback are in constant flux according to this allostatic model. In turn, the sensor-motor mappings (the level at which Seth ascribes a role for allostasis) are then constrained by the top-down perceived extrinsic demands that are required to be met and that in turn modulate the boundary settings of first-order feedback. While Position 2 implies re-establishment of set boundaries – to the range ideal for self-maintenance – following meeting of the extrinsic demands, Position 3 implies an effect on these bounds imposed by the degree of exposure to the particular sets of extrinsic demands. From a cybernetics perspective, Position 3 is more usefully conceived as an allostat (see also Muntean & Wright 2007, and Vernon et al. 2015 for reference), which regulates according to extrinsic/interactive norms. Position 3 appears to be consistent with, therefore, the interactivity account of Harvey et al., in the target article. Organismic regulation is interactive, according to changing social norms, to such an extent that constitutive organization of the organism “involves body-environment interactions” (§26). The physiological and metabolic activation patterns required to deal with such norms are necessary for organismic viability and comprise “lineage-general ways of maintaining […] molecular self-reproduction” (§26) focused on flexibility according to perceived demand that may vary over days, seasons, and the organism’s lifetime.

9 Extending the definition of allostasis given in Position 3, to emphasize further the links with Harvey et al.’s interactivity perspective, I refer to Schulkin’s (2011a, 2011b) term social allostasis. This notion entails “an evolved set of anticipatory mechanisms that facilitated the regulation of the internal milieu amidst an expanding social milieu” (Schulkin 2011b: 7). Critical to social allostasis is social competence and maintenance of social status (Schulkin 2011a,b). Feedback from the social milieu provides a type of predictive regulation differentially impacting on individuals in relation to perceived extrinsic (interactive) demands, i.e., disruptions of such social status and competence.

10 It has been argued that, for humans, fundamental to the evolution of cognitive capacities has been the simultaneous evolution of an adaptive stress response (Cummins 2012). Such an adaptive mechanism may have been necessary to accommodate the increasing allostatic load (wear and tear effects of stress) consequent to the expanding goal-directed temporal horizons and complexifying social milieu that confronted our early hominin ancestors (Cummins 2012). For socially complex organisms such as humans, constitutive regulation of individuals should therefore also be considered in terms of the social context in which the lineage has evolved. Essentially, predictive regulation of lower level constitutive processes is evolutionarily adapted to accommodate states of both an individual (intrinsically normative) and environmental (extrinsically normative) nature. From the perspective of Position 3, again, intrinsic normativity concerns the constraints imposed on the organ-
ism for adapting to extrinsic demands. The degree of complexity of social construction on an evolutionary and organismic timescale is such that organisms are required to be optimally flexible to deal with changing extrinsic/interactive demands.

> Upshot: On the above reading, the allostatic process is constitutive to a socially, and ontogenetically, constructed type of sense-making. Critical to debate is whether sense-making, so-conceived, can be captured within an extended cybernetic-enactivist framework of the type put forward in this commentary, or whether it is of greater explanatory value to adhere to the interactivity framework, as Harvey et al. propose.

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Authors’ Response
Explanatory Pluralism and Precise Conceptual Development
Matthew Isaac Harvey, Rasmus Gahrn-Andersen & Sune Vork Steffensen

> Upshot: We agree with commenters that enactivism incorporates a broad variety of methodologies, metaphysical stances, concepts, and investigative approaches, and that this is a good thing. However, we remain concerned that autonomy and sense-making are problematic concepts for post-Varelian enactivism, and that they form the foundations of a conceptual framework that may hamper the development of effective explanations for cognitive activity, as well as the paradigmatic aspirations of this particular enactivist approach.

Introduction

> 1 » We would like to thank all four commenters for their careful readings and thoughtful responses to our target article. They have advanced the discussion a great deal, and we are very pleased to see that our article has been read as we hoped it would be, and to participate in subsequent conversation. This is an ideal opportunity to do as we all agree we ought, and see what can be done to clarify enactivist concepts vis-à-vis interactivity-based approaches, and vice versa. We also want to say up front that we have no qualms about the enactivist label, or about enactivism as a broad collection of perspectives and research practices. We applaud efforts to take lived experience, Buddhist philosophy, and first-person perspectives into account in cognitive science. Our concerns are narrow but (we hope) quite sharp, and have to do specifically with autonomy, operational closure, sense-making, and intrinsic normativity.

> 2 » Our response is divided into two parts. First, we discuss the proposals made by the commentaries about an enactive perspective, and whether specific enactive concepts might be modified or adapted in response to our negative argument. It should be noted that, with one major exception, the commentaries all accept our core negative claim, i.e., that autonomy (strictly defined as precarious operational closure) and sense-making (strictly defined in terms of intrinsic normativity) are not, as they are currently formulated and discussed, compatible with massive hetero-scalarity of organizing influences on the activity of living systems. ¹ This is not to say that they agree with us, but rather that this claim precisely – as opposed to a more general antagonism towards enactivist accounts, or other particular issues – is not their target. The second part of the response deals with the one major exception to this, and addresses various related criticisms of our article.

Adding to autopoietic enactivism

> 3 » We can begin by agreeing with both Fred Cummins ($§6f$) and Tom Froese ($§2, 14$), who point out that enactive concepts are undergoing consistent development, and that they can be extended and modified to deal with explanatory challenges. Further, given the historical progression in enactivism’s research focus from cells towards socially and cognitively rich types of human action, it is reasonable that the existing concepts are not (or not yet) perfectly suited to the analysis of human life. Indeed, there is no reason our specific critiques of autonomy and sense-making could not be made from “within” enactivism; their purpose is to encourage re-consideration of the role played by certain concepts in developing explanations for behaviour.

> 4 » Robert Lowe and Nathaniel Barrett both engage in active re-consideration of this kind. Lowe proposes reconceiving enactivism in light of Peter Sterling’s (2012) notion of allostasis, described as the key characteristic of mechanisms for the regulation of biological activity. Importantly, of the three positions he describes (see §2), reactive homeostatic regulation and transient allostatic regulation describe systems characterized by operational closure (i.e., a strict concep-

¹ It is worth being precise here. There are many formulations and interpretations of the concept of “autonomy” in and around post-Varelian autopoietic enactivism. Some of these are less precise, or more open, or less central, or bear less explanatory weight than the one we have in mind. Our negative argument was that operational closure, under precarious conditions, (a) seems not to obtain as a literal explanation of operational dynamics for some biological systems and (b) cannot be the only source of norms that influence the organization of living systems. This means that modified, extended, or otherwise re-thought conceptions of autonomy and intrinsic normativity could avoid this critique; where commenters suggest such a course of action, we take them to be proposing a move away from the use of precarious operational closure as an explanatory concept.
tion of autonomy), while non-transient allostatic regulation describes operationally open systems. On our reading, this means no explanatory weight is given to the notion of operational closure, which is instead used purely as a descriptive tool, where and when that is appropriate. This allays our concerns about the concept’s over-use.

« 5 » Partly for this reason, we are sympathetic to Lowe’s position. What he describes as ‘cybernetic enactivism’ goes beyond post-Varela autopoietic enactivism on a decisive point, namely that it takes extrinsically derived norms into account. For this reason, Lowe suggests that interactivity and enactivism are compatible if the latter is understood in his cybernetic sense, as both approaches acknowledge that an agent makes sense of its world on the basis of both self-derived and other-derived norms. (A satisfying account of this would amount to crossing successfully the so-called cognitive gap, which, as Froese notes, has not been dealt with by autopoietic enactivist approaches.) There is some lack of clarity about how to understand “norms” in this discussion – it is not clear either in Lowe’s paper or in Sterling’s precisely what they are, whether we ought to speak of them as set or as instantiated, and so on – but this is a problem for the future. In general, Lowe’s cybernetic enactivism seems to us a helpful addition to the array of biological perspectives that can be used to analyze phenomena of interest.

« 6 » We are worried about one aspect of Lowe’s paper, however, which is that cybernetic enactivism seems to adopt a functional perspective on social behavior (see, e.g., §9, and footnotes 3 and 5). Whereas it makes good sense to conceive of some organismic activity in terms of functional descriptions, the same does not hold for human sociality. As one of us has argued elsewhere (Cowley & Gahrn-Andersen 2015), social and cognitive functionalisms are both problematic because they reduce individual sense-making to synchronous coordination (thus leaving aside the vital asymmetry between agent and environment that is central to autopoietic enactivism), and because they leave little room for phenomenology (thus precluding useful examination of lived experience).

« 7 » Barrett proposes a similar answer to our concerns. He sees no reason why enactivists cannot allow that extrinsic normative influences affect activity without giving up their account of intrinsic normativity (§10f). Additionally, he suggests (§9) that the core of the enactive notion of sense-making is asymmetry of organism-environment coupling rather than the operational closure of living systems – that this asymmetry is both more explanatorily important and of greater conceptual interest. Certainly, we have no quarrel with Barrett’s suggestion that a single account might give due attention to both agent-external normative influences and those normative influences arising from processes that constitute the agent. We see our target article as an attempt to contribute to just such an account. The trouble is that, as far as we are aware, the concepts of normativity and organism-environment asymmetry are both defined in terms of autonomy, construed strictly as precarious operational closure. According to both Ezequiel Di Paolo (2005: 434–437, 443) and Evan Thompson (2007: 145–155), the fundamental asymmetry of living systems with respect to their environments consists precisely in the fact that, through their persistent molecular self-organization and self-production, they distinguish themselves as coherent entities. In addition, the intrinsic normativity of these systems is identical to their self-production, as ongoing self-maintenance becomes a norm that in fact organizes each system’s activity – otherwise it dies (for extended discussion see Barandiari & Egbert 2014; Barandiari, Di Paolo & Rohde 2009).

« 8 » For this reason, we have serious doubts about Barrett’s optimistic assertions. Organism-environment asymmetry seems neither more nor less important than autonomy in this account, because it is identical to it. And neither is it clear that extrinsic norms can be added to an autopoietic enactivist account, just because the only way to make sense of “normativity” that is currently available in the post-Varelian autopoietic framework is in terms of parameter constraints arising from the self-organizing of autonomous systems. Other conceptions of normativity might be added, such as, for instance, Pierre Steiner and John Stewart’s contribution that suggests that individuals adapt to social heteronomy through intrinsic (pre-)dispositions (Steiner & Stewart 2009: 536f). However, they provide no explanation of how an agent comes to form such dispositions in the first place without violating its operational closure. For this reason, we do not see a principled way of explaining human social encounters that keeps the existing conceptions of autonomy and sense-making firmly in place. Barrett asks, in §10, why organism-environment coupling cannot be both self-regulated and heteroscalar. It is crucial to any interactivity-based account that it can be, and is. Our concern is that this is very difficult or impossible to capture if “self-regulation” consists of intrinsic normativity, as that concept seems to preclude heterogeneity of organizing influences. The reason for this is that some heteroscalar activities play out on the basis of extrinsic norms that do not emerge from the agent. So to be clear, our disagreement is with a very specific notion of self-regulation (seen specifically in relation to the paradigmatic aspirations of post-Varelian enactivism and to autonomy as a core concept of this particular enactivist approach), and not with self-regulation construed in some other way.

Maturana and Varela

« 9 » This brings us to the direct critiques of our target article. We begin with those raised by Froese, who clarifies and corrects some of the details of our overview of Humberto Maturana, Francisco Varela, and post-Varelian autopoietic enactivism. The chief issue here is that our interpretation of the two authors presents Maturana’s position as more open and flexible than that of Varela (aligning, respectively, with what we call “organizational closure” and what we call “operational closure”). Froese is concerned that this may be inaccurate, and indeed, that the relationship may be the other way around (see §§4–6, and §§7f, 10f, respectively). We will engage with sev-

2| An added complication here is that in cases where a single organism is constituted of multiple autonomous systems – for instance, when an organism’s nervous system displays self-sustain-
eral aspects of this issue with a view towards clarifying our target article.

10 We agree that Maturana’s work “lends itself to conflicting interpretations” (§4); perhaps more to the point, it requires active and creative interpretation to derive any clear claims from it at all. This applies especially for his most general ideas, such as the discussion of domains of operations. Froese suggests, and we agree, that the passage he quotes can be read as a clear commitment to operational closure in our terms, such that it does make “particular claims about the operational dynamics of living systems”, and does preclude non-molecular processes, and processes outside an organism’s operational bounds, from constituting it as an entity. On this reading, we (in our §17) are far too generous to Maturana in attributing to him a view that is compatible with organizational closure – again, in our use of that term.

11 But to be frank, it is difficult to make sense of Maturana’s talk of “non-intersecting domains” in clear terms. At the very least, it admits of several alternative readings. For instance, if read (in the manner Froese suggests) as the claim that processes whose operational constituents include, say, muscles, cannot causally affect processes involving molecules as operational constituents, it seems clearly false (e.g., the beating of an animal’s heart has causal effects on the ongoing health of cells in its extremities; if the heart’s dynamics are disrupted, those cells will quickly find that their molecular milieu lacks sufficient oxygen molecules, and they will die). So we read it, instead, as a metaphysical claim concerning the concept of autopoiesis in relation to the experiencing human observer, who is given strict injunctions not to think that autopoietic organization (as a characterization of whole organisms) has causal effects on whole-organism events, such as anatomical movement. We read it as a metaphysical claim because it is about the type of existence that living systems have (e.g., “systems as composite entities have a dual existence [...]” Maturana 2002: 12), and also because the domains and their relations are defined in terms of distinctions drawn by the experiencing human observer (e.g., “the generative relation that an observer may see between these two domains is a historical relation that the observer makes [...]” ibid).4

12 In addition to these considerations, there is the nature of the idea of autopoiesis. Maturana writes that “[he] proposed it as an abstraction of [his] biological understanding of the biological knowledge of the times” (ibid.: 7). At greater length:

“…My assertion that living systems are molecular autopoietic systems is neither a definition nor an explanatory proposition, it is an abstraction of the operational coherences apparent [i.e., seen by an observer] in the actual living of living systems as molecular systems. Therefore, my assertion that living systems are molecular autopoietic systems (and that there can be autopoietic systems only in the molecular space) is a claim about what constitutes living systems, a claim about how they arose, and a claim about how they operate in the pragmatics of their living. Moreover, as I have already said, as I claim that living systems are molecular autopoietic systems I do not make a claim about any particular molecular structure in them, rather I make a claim about the kind of molecular net-work that constitutes them.”5 (Maturana 2002: 11, our emphases)

13 Given the lack of clarity attendant to his use of “constitutes”, “arose”, and “operate”, the only genuinely clear statement here is that autopoiesis is neither explanatory nor definitional, but is rather an “abstraction” of what is “apparent” to biologists. It is probably worth noting that this arguably reflects a change in perspective from his earlier work. Whereas in these 2002 quotes, Maturana is explicitly defining autopoiesis as an abstraction, in the 1970s and 1980s, he used it as something more of an explanatory concept. For example, he offers an account of nervous system operation in terms of its functional closure, suggesting that it undergoes change on the basis of its self-referential properties (Maturana & Varela 1980: 25). In taking autopoiesis to pick out the universal constitutional property that characterizes any living system at all points in time, the later Maturana seems to take on a philosophical rather than a biological position – and as such, what he says is less restrictive with respect to the actual operations of specific systems in particular situations. In this light, how are we to make sense of this line from the passage Froese quotes?

“…The constitution of living systems as autopoietic systems entails their constitution as organisms as a result of the constitution of their operational boundaries which separate the molecules that dynamically participate in their autopoiesis from those that do not.”5 (Maturana 2002: 15)

14 If this, too, is to be read in terms of an abstraction away from what biologists observe as they go about studying organisms, then:

• it does not specify anything about the temporality or direct causal dependencies among processes involved in constituting organisms, and
• it must in principle be general enough to account for the wide range of phenomena biologists encounter.

15 The latter property is conceivably just a matter of abstraction, so no more needs to be said about it. The former seems to be justified by certain other statements he makes regarding the two domains, or the “dual existence of living systems” (Maturana 2002: 12). The distinction between the domains is a distinction between, on the one hand, the abstract autopoietic processes that constitutes the system as living and, on the other hand, the concrete domain wherein the living system works as an organism and interacts with its environment (he calls this the “supra-molecular space”, ibid.: 14). He writes, “an organism is an autopoietic system through its molecular composition, not through its supra-molecular existence” (ibid.). It seems reasonable to understand this as the idea that the organism as a whole may in fact be operationally open just as long as extrinsic norms and processes do not bear directly on its (abstract) organiza-

3 This example is more complicated than it may appear at first. On the one hand, it seems to be internal to the organism’s physiology, and so seems to fit with Froese’s interpretation of Maturana. On the other, there is reason to think that heart-rate can become coupled between people (Kovvalnika et al. 2011; see discussion in Stefansen 2015: 11f), suggesting that these muscular contractions may be directly coupled to extra-bodily processes.

4 We have chosen quotes from the same paper Froese refers to in order to avoid the changes in Maturana’s position over time that he mentions.
tion as a living system. This interpretation fits perfectly well with the doctrine of non-intersecting domains, which is the idea that “the relation between these two domains is not causal; these two domains do not intersect, nor do the phenomena which pertain to one occur in the other” (ibid: 12). Considerations along these lines led us to say that perhaps our own view might be usefully described as in line with Maturana’s – or at least, with this later, early-2000s Maturana. By contrast, it seems to us that Varela – agreeing with, or perhaps following, the earlier Maturana who wrote “The Biology of Cognition” (Maturana & Varela 1980) – gives explanatory weight to operational features such as “closure”, whether organizational or operational in our terms, and uses them to understand (for example) the function of the nervous system (e.g., Varela 1992, 1997).

“16” But it is crucially important that we do not get too sidetracked by conflicting readings of these texts. Our project was not exegetical in nature. Froese’s response makes it clear that our conception of organizational closure is not necessarily “Maturanian”, and that even the labels we use later – “Maturana-derived”, “Maturana-inspired” – suggest too close a connection. Let us say this: we take it that living systems are characterized by closure among “an abstract specification of the set of relations that obtain among the system’s repeating component processes so long as the system persists” (§14), such that “circular molecular organization might, without contradiction, be realized operationally by non-circular, constitutively open and environment-involving, massively distributed and multi-scalar processes” (§17). Eating and breathing are processes of this kind. Although Maturana would say that they are “in the relational domain”, nonetheless they are stable, indispensable, enabling conditions for the ongoing molecular self-creation of many lineages.

“17” Froese also says that we attribute too little to Varela and to post-Varelian autopoietic enactivism, in addition to attributing too much to Maturana. It is worth stating that even the labels we use later – “Maturana-derived”, “Maturana-inspired” – suggest too close a connection. Let us say this: we take it that living systems are characterized by closure among “an abstract specification of the set of relations that obtain among the system’s repeating component processes so long as the system persists” (§14), such that “circular molecular organization might, without contradiction, be realized operationally by non-circular, constitutively open and environment-involving, massively distributed and multi-scalar processes” (§17). Eating and breathing are processes of this kind. Although Maturana would say that they are “in the relational domain”, nonetheless they are stable, indispensable, enabling conditions for the ongoing molecular self-creation of many lineages.

“18” Our own distinction – given in §14 and footnote 6 of our target article – is motivated by the usage of David Rudrauf and colleagues, who write,

Moreover, there are two aspects of closure: organizational, which defines the possible interactions in a ‘static’ circular framework, and operational, i.e., the recurrent dynamics that closure elicits. (Rudrauf et al. 2003: 34, emphases in the original)

“19” On their reading, Varela’s concept of closure (sometimes called organizational, sometimes operational, according to them) had both of these aspects. Our target article proposes a modification to this scheme, on which organization is strictly an abstract characterization of relations among repeating processes (meaning that it does not capture either the dynamics of a system’s activity or non-repeating processes), and operation refers to the actual activity–in-time of a particular specifiable system. Thus systems can be organizationally closed without being operationally closed, using our terminology.

Autonomy and normativity

“20” Froese also argues that the conceptual development by Varela, Di Paolo, and others that leads to the present notions of autonomy and adaptivity is precisely what makes it possible for enactivism to engage with “constitutive dynamics that incorporate normatively organized behaviors that are distributed and environment-involving” (§8). We agree with his positive evaluation of the emphasis on organism-environment interaction rather than on organisms alone, and we agree that the examples he provides are compelling ones. But our concerns stand. For instance, he refers to the example given by Di Paolo (2009b) of an insect able to survive underwater temporarily by trapping air bubbles against its body; in that paper, Di Paolo raises the conceptual possibility of the same insect finding a way to renew the bubbles underwater, and so remain there permanently. Such a creature would be “alive and not sensu stricto autopoietic” (ibid: 64), and indeed, not operationally closed, as only the insect’s interactional activity of collecting oxygen – rather than one of its constitutive processes – would enable its ongoing metabolism. On the basis of this and other examples, we are to believe that enactivism is capable of addressing heterogeneously constituted multiscalar organization of activity.

“21” But we argue in our target article (§§28f) that non-fictional examples of non-operationally-closed living systems abound. Non-autonomous systems are not an exception to the rule, they are utterly ordinary. Indeed, it is difficult to conceive of any multi-cellular organism as being strictly operationally closed, and even harder to imagine how we might ascertain whether this is the case. And this is without taking into account our concern that many or most organisms are constitutively multiscalar, such that their behaviour takes into account norms and values extrinsic to the agent itself. On our view, non-autonomy ought to be the default assumption for researchers interested in the sorts of phenomena that enactivism, and interactivity-based approaches, are interested in.

“22” We feel that Froese’s other examples support this view. For instance, work on participatory sense-making (beginning with De Jaegher & Di Paolo 2007) has focused on emergent self-organization in the dynamics of face-to-face interaction. People’s movements in these cases can evoke movements in their partners, leading to partially self-sustaining patterns of activity, such that the interaction itself can be seen as an autonomous system, with its own intrinsic norms (at least, the norm of self-persistence). For
Froese, Varela’s substrate-neutral conception of autonomy is very helpful here, as “it permits us to study individual behaviors and social interaction dynamics in terms of two interdependent yet mutually irreducible domains” (§11). But are the “social interaction dynamics” actually a different “domain” from the movements of the interaction participants? (Again, “domain” is an unclear term; “different” here means, in Froese’s words, “irreducible” yet “interdependent”). Do the movements exist as non-social activity? More importantly, when human movement does not form a set of hierarchically arranged autonomous systems – say, when someone goes for a run – can it still be social behavior? Di Paolo (2009b: 54) and Froese (§10) both propose, similarly, that habits can be seen as self-sustaining, circularly organized patterns of activities. This may be correct, but what advantage is gained by noting it? It seems to us that the generalized notion of autonomy is little or no explanatory work in these cases. It serves only to direct researchers to areas of behavior that seem to comprise circularly organized systems, as opposed to behavior that is more variously organized.

A related concern is voiced by Barrett, who says several times (most significantly in §9) that he sees no reason to read definitions of autonomy, adaptivity, and sense-making as being monoscalar concepts. He is right in the sense that, as far as we are aware, they have only once been explicitly discussed in relation to the question of timescales. However, on the one hand, they are exemplified using examples of monoscalar coupling, e.g., the coupling of bodily movements (De Jaegher & Di Paolo 2007), the coupling of bacterial flagellation to sucrose gradients by means of chemosensation (Di Paolo 2005: 445; Thompson 2007: 147), and so on. Second, coupling in general is a matter of constraints on the parameters of one system by the activity of another; the timescales on which it takes place are therefore determined by the dynamics of the coupled systems. And again, enactive discussions of autonomy, adaptivity, and so forth have focused on cellular regulation of ion concentrations, nervous system activity, and anatomical movement, usually one at a time. This means that, just as a matter of fact, they have tended to focus on coupling on single timescales. It is possible to define operational closure such that it applies to processes on multiple timescales, but it is not clear whether the relevant properties, such as “self-production”, still make sense in these cases.

There is also another side to this issue, which is to treat it as a question about the “here and now” rather than about monoscalarity. According to Barrett, we do not provide any evidence that autopoietic enactivism confines itself to a situated, “in the moment” perspective. However, it is at least worth recognizing that in the enactive literature, there are many examples of focus and emphasis lying on the here and now, even if there are not explicit restrictions on what is to be considered as an explanatory resource. Varela argued explicitly in favour of a situated enactive approach, placing strong emphasis on the emergence of phenomenological experience from moment to moment (see, for instance, Varela & Shear 1999: 115f). He underlines his position in other writings (e.g., Varela 1987; Varela, Thompson & Rosch 1991) using the metaphor of “laying down a path in walking”. More recently, other enactivists including Hanne De Jaegher and Di Paolo (2007) and Elena Cuffari (2014) have argued extensively that human social life plays out on the immediate level of inter-bodily coordinations and/or through in situ linguistic interactions. With respect to language, Cuffari writes the following:

“Although we are trained, as scholars and users of language, to attend and deal primarily with words, I suggest that deeper listening and more mindful engagement result when we understand words as in-the-moment interactions with experience.” (Cuffari 2014: 211f)

However, linguistic activity, or languaging, is also constrained by factors that do not play out in a situation but condition it nonetheless. This limited focus of autopoietic enactivism means that topics related to languaging are excellent subjects for interactivity-based approaches.

Questions of metaphysics

There is one other issue we would like to address, which is Cummins’s challenge to the “objective key” of our approach to explanation, and to our metaphysical stance in general. In particular, he is concerned that we ignore that enaction is not “part of an objective science of biology, concerned with individuated discrete organisms” (§2). To further his argument, he contrasts “the manner in which creation is treated in Buddhist and in Christian cosmologies” (§3), with a starting point in the Buddhist “core concept of dependent origination (pratityasamutpadta)” (§4), and the two views on time related to John Ellis McTaggart’s (1908) distinction between linear time and the lived experience of time. Cummins’s main point seems to be that “[i]n a strongly constructivist, enactive key, experience is prior to any distinction between subject and world” (§4). Cummins is to be applauded for addressing the big issues in this debate, and in particular for highlighting the Buddhist philosophical thinking in Varela et al. (1991). However, we remain unconvinced by his argument.

5| Di Paolo (2005: 444f) offers a characteristically clear and rigorous account of the “minimum temporal granularity” established by a system’s ability to regulate its activity as part of self-maintenance. That is, when an organism’s activity operates to correct a tendency that threatens its autonomy, the activity takes on the structure of circularly organized systems – say, when an organism’s activity operates to correct a tendency that threatens its autonomy, the activity takes on the structure of circularly organized systems. This may be correct, but what advantage is gained by noting it? It seems to us that the generalized notion of autonomy is little or no explanatory work in these cases. It serves only to direct researchers to areas of behavior that seem to comprise circularly organized systems, as opposed to behavior that is more variously organized.

6| As Froese notes (personal communication), this is another legacy of Maturana’s early writings (e.g., Maturana & Varela 1980: 18).

7| The expression “prior to” is odd, since that actually presupposes a linear concept of time.
Notice that we did not talk about “an organism’s experience as ‘being coupled to the world’” (our emphasis) but about “organisms’ experience of being coupled to the world” ($13, our emphasis). Clearly, there is nothing contradictory in a model of dependent origination and a model of experience where one part of the co-arisen dyad experiences its coupling to the other part. In fact, were that not the case, the Buddhist doctrine would have been empty speculation: its explanatory power comes from the fact that it builds on his analysis of his experience as something that is not “his” (in the meaning of something private, apart from the world) but a relational and fluctuating aspect of the co-arisen dyad. Borrowing the words of Eleanor Rosch, we must understand experience in terms of “a seamless whole or seamless web, in which perceiver/categorizer and perceived/categorized are simply opposite poles of the same event” (Rosch 1999: 71).

Overall, we find that Cummins misrepresents our commitment to (some variety of) naturalism and realism. Cummins relies on a rhetorical model that contrasts Buddhism and enactivism with the “usual suspects”: the Copernican-Galilean-Newtonian-Cartesian world view” ($3), which “has no place for mind” ($3), and which takes Christianity as its “unacknowledged [metaphysical] background” ($3). Between these two positions, tertium non datur. However, that is a non sequitur. Our interactivity-based approach is exactly an attempt to reconcile a naturalised world view with an emphasis on life and experience. In short, the interactivity-based approach takes a starting point in an extended ecology (Steffensen 2011) that represents neither a mindless, mechanistic ontology nor the view that experience occupies a privileged position in our ecologically embedded existence.

As presented in the target article, our approach presupposes the notion of temporal multiscalarity. This notion contrasts with Cummins’ claim that “subject and world arise in the always-present now” ($4). To understand fully what is at stake here, let us follow Cummins’ route and consider some of the Buddhist philosophical underpinnings. If we accept the doctrine of paticcasamuppada, it follows that all co-arisen phenomena are in a state of impermanence (anicca), because “things” that are co-arisen do not owe their existence to any inner, transcendent qualities – they are suihatā (empty), as described in the Buddhist doctrine of anatta (no-self). The key to understanding this philosophical system is to appreciate that it is primarily an attempt to grasp the temporal dynamics that play out in our lives. Paticcasamuppada, on this view, is a theory of causality, rather than a cosmology. It argues that our being is an interbeing and that the temporal flow of our existence is not tied to autonomous bodies, because they, in themselves, are “empty.”

On this view, no causal power stands outside what one of us has termed “the paticca field;” i.e., the open-ended system of co-arisen entities in the world. In later Buddhist philosophy, most notably in the Chinese Huayan tradition (Fox 2009), the term interpenetration has been used to illustrate this radical view of interbeing (cf. the metaphor of Indra’s net). Giving experience a privileged metaphysical status, as Cummins does, thus seems misguided. Experience is no less and no more than an explanans: it too must be grasped within a larger network of existence. It is for this reason that we adhere to a naturalist position: to understand experience requires that we understand the causal interplay, or the interpenetration, between experience and the Paticca field at large. However, since some of the temporal dynamics in the Paticca field happen infinitely faster, and others infinitely slower, than we can experience, we see no way in which a first-person perspective can grasp that interplay and interpenetration. Borrowing the words from the Norwegian poet Bertrand Besige: “Og du dør så langsomt at du tror du lever” (“And you die so slowly that you believe you live”). In fact, the pivot of the Buddhists philosophy is to show that pain and suffering (dukkha) arise because experience and reality are not tightly coupled or synchronized.

The Paticca field has no spatiotemporal limits, and thus no center. It is multi-logical, multi-scalar, and multidimensional, and it gives rise to a flux of transient, interrelated, and interdependent events that occur in series of arising, being and ceasing (“the ABC of impermanence”). One such event is the co-arising of experience. We trace experience to the emergence of life, i.e., a set of irreversible temporal dynamics that de-synchronises the interbeing of organism and environment (experiencer and world). Thus, understanding the exact temporal dynamics that play out between different complex systems, and hence between organisms and their environment(s), is a way of establishing a multiscalar framework for understanding life. These dynamics may vary in complexity, and human cognition (and human lived experience) is vastly complex, and not just because it plays out on more timescales than, say, those of Chlamydomonas nivalis. What is so astonishing about human life is that human beings have learnt not only to enact different timescales but to “create and inhabit their own temporal domains” (Cowley & Steffensen 2015: 490), which has made us into time-rangers (ibid), agents capable of flexibly operating in many different temporal scales.

With respect to Cummins’ comments, then, we hope to have made clear that we are not indiscriminately blending two incompatible ontologies. While the above account is obviously sketchy and superficial, we hope that it indicates our overall approach to understanding how “lived experience” can, and indeed should, be traced to the totality, the Paticca field, from which experiencer and world are co-arisen, and not to the “world” as an objective phenomenon outside the experiencer. To the degree that such a model can be further developed, we maintain that our interactivity-based approach has potential for understanding lived experience.
experience against the backdrop of a naturalised and realist ontology.

There is a great deal in the commentaries that we have left unanswered, in the interests of keeping this response shorter than the original target article. The upshot, we think, is very positive. We see no reason to adhere strictly – or to reject – post-Varelian autopoietic enactivism, or its core concepts. Better by far to accept the co-incidence of various alternative models, which provide complementary means of accounting for wide ranges of organizational influences. In effect, we suggest making the move recommended by Barrett (to stipulate that external norms, as well as intrinsic ones, play a role in sense-making), which might be done using an interactivity-based framework, an allostasis based framework as proposed by Lowe, or a different framework altogether, in an attempt to develop a clearer picture of how groups of people collaborate in collectively organizing activity. To borrow Froese’s way of putting it, we are after “an explanation of how, in that very moment, the operations underlying the individual’s choice of action were realized in accordance with […] cultural norms” (§14). It is still not clear to us whether this can be achieved within the post-Varelian enactive paradigm. We still have strong doubts that it can, so long as autonomy and sense-making remain, unchanged, at the center of that paradigm’s conceptual apparatus. But as we have discussed, the concepts are flexible; the method that has been used to develop them can be used to develop them further, and potentially to apply them to new phenomena in light of our criticisms. And in addition to this, it is clear that other enactivist concepts, approaches, and perspectives are helpful in their own right, and will contribute to our understanding of cognitive activity.

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**Combined References**


