Empowering Biosemiotics

Charles Lassiter
Gonzaga University
charles.lassiter@gmail.com

Abstract One way to understand the basic semiotic relation is that a sign-vehicle signifies an object to an interpretant. Biosemioticians sometimes talk about this relationship in terms of "codes". When thinking about this relationship in the context of language, a natural move is to conceptualize semiotic relationships among speakers, meanings, and utterances as codes: speakers encode messages in sentences, which are then decoded by an interpreter. This view of communication is inconsistent with core tenets of a distributed approach to language, which holds that language is an embodied and encultured activity taking place across multiple timescales. I argue that a neo-Aristotelian metaphysics can be of help. A sign's pointing to an object for an interpreter is a triadic relation, which can be described in terms of "abilities" or "powers". On this view, talk about "codes" is eliminated in favor of talk about powers of agents and utterances.

0. Introduction

In book 2 of *The Odyssey*, we're introduced to the long-suffering Telemachus and Penelope. Odysseus has been gone for many years. Suitors have set up in his house, attempting to woo the presumed-widow Penelope. But in the meantime, they are eating Penelope out of house and home. Telemachus, Odysseus's son, summons his courage and demands the suitors leave. The suitors, he declares, are consuming Odysseus's estate with their bottomless appetites, and they must quit living off the fruits of his labors. Zeus sends his approval of Telemachus: two eagles tearing each other apart. Halitherses, a townsman and prophet, reads this as a sign of the suitors' impending death. The suitors, says Halitherses, would be wise to leave and never return, lest they secure their own deaths. Eurymachus, a suitor, interprets the sign as meaning good fortune for the suitors and doom for Telemachus. Skipping ahead a few hundred pages, we learn that Halitherses is right and Eurymachus wrong.

Although we no longer put stock in the actions of animals to scry the future, we present-day people attend to signs as much as the ancient Greeks and their forebears. A fever is a sign of infection; a cross on a necklace is a sign of one's religious commitments; conservative American politicians use "socialist" to signify policies they

don't like. Since the ground-breaking work of von Uexkull (1934/2010), Bateson (1972, 1979), Hoffmeyer (1993), Wheeler (2006), and Sebeok (1979, 1987), among others, we have conceptual resources for framing how not just humans but all living things use signs: to be alive is to be a producer and consumer of signs. Slime mold is a fascinating case. This simple organism "remembers" areas it has explored by leaving behind a chemical layer. This cue is a sign to the slime mold that, when searching for food, it should explore elsewhere.[1] The slime mold responds to the chemicals as a sign indicating previous exploration.

The distributed language approach (hereafter "DLA") seems at a first glance to fit biosemiotics like a glove. DLA, in a nutshell, conceptualizes linguistic activity as distributed across time and space — more on this later. What are some of the similarities? First, DLA rejects the many of the internalist assumptions of Sassaurean-inspired linguistics, as does biosemiotics. Next, an emphasis on embedded and embodied cognition in languaging would seem to put DLA-advocates on the same page as biosemioticians. Both embrace a hard-nosed naturalism; recognize the impact of culture on cognition; begin on the assumption that minds are deeply embodied; and acknowledge a continuity between mind and life.

However, not all is as copacetic as one might hope. One strong theme in biosemiotics is understanding signs as codes. Barbieri (2008, 2010, 2012), for example, says that a scientific biosemiotics *requires* "code" as a theoretical construct[2]. Hoffmeyer (1996), often leans on the metaphor of codes to talk about how living organisms relate to signs. DLA, on the other hand, eschews talk of codes[3]. This is a serious obstacle to an otherwise fruitful partnership.

One of the differences is metaphysical: biosemiotics countenances the existence of a theoretical entity that DLA does not. A metaphysic that could unite these two theoretical viewpoints would need to find a way to overcome this roadblock. What are the desiderata for such a theory? Here's one intuitively appealing set:

1. The theory has the resources for describing language as a distributed phenomenon.
2. The theory is amenable to the tripartite relationship among signs, objects, and interpretants that is characteristic of Peircean semiotics. In particular, this theory would have to have the conceptual resources to express these relationships.
3. The theory has posits which satisfy the functional role of codes in biosemiotic theory.

---

[1] «How brainless slime molds redefine intelligence», https://www.nature.com/news/how-brainless-slime-molds-redefine-intelligence-1.11811

[2] Barbieri's code approach to biosemiotics is the foil for this paper, but developments in his thought complicate things a bit. His (2014) paper, "From Biosemiotics to Code Biology" represents a significant change in his thought. No longer, Barbieri says, is biosemiotics sufficient as a theoretical apparatus to introduce meaning into biology. Code biology is what's needed. While this is an important development for biosemiotics and code biology, it certainly complicates the arguments here. To simplify the foil for the position I develop, I ask the reader to imagine my dialogue partner in Barbieri to be *not* the post-2014 Barbieri but rather the pre-2014 Barbieri. Pre-2014 Barbieri has a particularly detailed development of the role of codes in a biosemiotic theory, so I take it as representative for a class of views in biosemiotics that describes language as code-like. I'm grateful to an anonymous reviewer for this suggestion.

[3] An exception to this is Cowley's notion of "wide coding".

_____

In this paper, I'll propose that a neo-Aristotelian metaphysics of powers satisfies these three desiderata. Powers, in brief, are capacities organisms have to initiate or undergo some change. They are properties that enable organisms to do what they do. I'll argue that Peircean semiotics can be developed in terms of powers, which obviates the need to appeal to codes as a theoretical primitive. The preferred metaphysical theory is *causal powers realism*. After brief overviews of causal powers realism, DLA, and biosemiotics, I'll show how causal powers realism satisfies the above three desiderata. I'll close with a brief discussion of the implications of casual powers realism for the concept of symbols. Given that uniting DLA and biosemiotics is a bit of a project, what's the value? Why bother doing it [4]? The first is that the project of integrating DLA and biosemiotics helps make explicit what is already implicit in DLA. The distributed language approach already inclines towards a broadly biosemiotic approach to language, looking at language as a phenomenon happening across multiple timescales and drawing on both local and non-local resources. The integration project in the paper then is a clearing away of superficial differences to emphasize that distributed language theorists and biosemioticians are working on similar projects, though from different angles.

The second upshot is a bit more daring. Causal powers realism focuses on agential powers — that is, what it is that agents do and undergo. DLA and biosemiotics agree that these powers are the products of both what is internal and external to an agent. One area in which DLA excels is in individual case studies (cf. Steffensen 2016). Steffensen's approach of cognitive events analysis, for instance, focuses on details of interactions. This is necessary. Likewise necessary is the view of how individuals fare as members of large, socio-cultural collectives. This approach is developed by e.g. Secchi and Cowley (2016, 2018), among others, in using agent-based models. But the biosemiotic-DLA synthesis points to something even broader: use of large datasets to understand why people interpret signs as they do. This is a strategy that's already been adopted, after a fashion, by large tech companies like Google and Facebook with A/B testing. In brief, A/B testing is making small changes (e.g. in a button's font color) and then comparing outcomes (e.g. number of clicks). How does this fit into the biosemiotics-DLA synthesis? Briefly, the font color is part of a symbol. As part of the symbol, it plays some role in signifying. If it turns out that changing the font color generated more clicks, then we'd have learned something new about humans' semiotic activities: in at least some instances, the different color prompts more clicks. This gives us a phenomenon to be explained using resources of both biosemiotics and DLA.

1. Causal Powers Realism: a brief introduction

Anything that is causally efficacious has powers. A rock has the power to break glass and glass has the power to shatter; rabbits have the power to hop and dogs have the power to run. Rocks, glass, rabbits, and dogs are capable of doing what they do in virtue of their powers. Powers are conceptually close to Gibsonian affordances (Vetter 2018). If an object affords sitting, then it has the power to be sat upon. A hill that affords climbing has the power to be climbed.

The view I advocate is *causal powers realism*. There's much to say about it (Vukov and Lassiter 2020; Lassiter and Vukov, forthcoming), but I'll focus on three commitments. First, causal powers realism is committed to the idea that powers are manifested in conjunction with what we'll call "manifestation partners" (Heil 2003). Consider salt's power of solubility. According to causal powers realists, salt does not manifest this power on its own but only when it is conjoined with a manifestation partner — for

_____

[4] Thanks to an anonymous reviewer for suggesting this point.

example, water's power to dissolve salt. Or consider another, more complex example. A bat has the power to echolocate. It manifests this power in conjunction with a space in which the soundwaves produced by the bat are able to bounce off of objects and guide the bat towards its prey. The bat's power to echolocate not only requires on-board capacities of the bat to produce and detect sounds; it also requires objects to bounce off of and, equally important but perhaps less obviously, a medium through which sound waves can travel. The bat's manifesting its power to echolocate depends on a host of other powers possessed by entities in the environment.

Second, causal powers realists are committed to the idea that manifestations of powers are themselves powers (Jaworski 2016). Consider, for example, a match. It has the power to ignite when its powers are combined with the powers of a high-friction surface. When the match is struck, it manifests its power to combust. Its being lit is a manifestation of a power it has. Now, the ignited match is itself empowered: you can start a campfire with a lit match but not an unlit one. The match's being lit — the match manifesting its power to ignite — is a power, and the lit match is empowered to start a campfire. And burning logs are empowered to toast marshmallows in a way that non-burning logs aren't. Causal powers realists describe this as: the manifestation of every power is itself empowering.

Finally, causal powers realists are committed to powers having lineages. A lineage is the historical dimension of a power; it is a power's development. For instance, my power to read didn't spring up overnight. After years of exposure to my parents readings to me, my teachers pointing to inscriptions and making certain noises, and reinforcements of various kinds, I was able to read [5]. That's to say that my power to read has an ontogenetic dimension, but a power's lineage is more than ontogeny. It also includes evolutionary and cultural histories as well. Humans can do the things that they do, in part, because of the development of their respective cultures. Human bodies, for example, have developed over millennia to be the kinds of entities that are capable of reading[6]. Having eyes that foveate as ours do and brains that work as ours do are products of evolutionary forces and part of the story for how we're capable of reading. If our visual systems developed like rabbits or chameleons, with nearly 360-degree vision, then reading would also look very different. Additionally, I could not read were it not for being raised in a literate culture. Cultural conditions are a part of my power to read.

One more point about lineages: they aren't mere sequences of past events. They function rather like the process of sedimentation (Husserl 1948/1973), "building up" over time. My power to read developed incrementally, each step forward building on the last. But lineages also point towards the future, opening up and constraining possibilities. When I was learning to read, for example, I learned to do it in American English. My power to read extends to texts written in that dialect but not in, say, Turkish or Hindi or Salish. The lineage of my power to read certain texts points to my being able to read some texts but not others: I can read social media updates with little difficulty, but Chaucer poses some problems. But this point goes for all powers: my power to bake a loaf of sourdough empowers me to bake a loaf of rye but not a tray of scones. My power to ride a bicycle empowers me to ride a tricycle but not a unicycle. Powers' lineages, then, are both *backwards-looking* and *forwards-looking*. They are backwards-looking in the sense that lineages are histories of how powers come to be.

---

[5] See Trasmundi and Cowley (2020) discussion of the development of the mechanisms for reading as they relate to the imagination.

[6] This claim isn't as robust as modularity theorists who claim that our capacity to read is the product of an evolutionarily-shaped module. The minimal claim here is just that evolution of the human species is going to be part of the story for how we're capable of reading.

They are forwards-looking in the sense that future manifestations are constrained by how the power came to be at that time.

This brief gloss of causal powers realism suggests a further point about manifestations of powers: they incorporate nonlocal resources. Manifestations of powers aren't restricted to what's available in the here-and-now but rather draw on spatially and temporally distributed powers. I'm able to read, in part, because I live in a literary culture and because of the widespread availability of books. That's to say that my power to read isn't informed only by ontogenetic forces but also by phylogenetic, social, and cultural historic resources. And reading isn't unique in this way. Many of my powers — from paying for a pint to downloading an app to voting — are the product of a host of powers, each of which with their own histories. That is to say, many of the things I can do are possible because of the manifestation partners in my present environment and because of the histories of both my own powers and those of the environment. All of these ingredients — both the local and non-local, the present and the historical — are necessary for an understanding of a manifestation of my skills.

There is a lot more to say about causal powers realism, but this will suffice for now. In summary, nonlocal resources are incorporated into a manifestation at time *t* by means of powers that are exercised in the environment. Any manifestation of a power — including living organisms' powers to respond to signs — is a result of long and tangled histories and presents.

2. Distributed Language Approach

There are many overviews of the DLA approach and as many detailed studies (cf. Harris 1987; Kravchenko 2011; Trasmundi and Steffensen 2016; Harvey, Gahrn-Andersen, and Steffensen 2016; Cowley and Kuhle 2020). It's not feasible to cover the many aspects of the DLA approach in this paper, so we'll hit only the highlights.

DLA is very conscientious in rejecting the Platonic-Cartesian axis within the history of Western philosophy. It places little stock in cognitively internal entities or centralized and non-emergent grounds of norms. It actively rejects the 'telementation' model of communication, in which thoughts are mapped to a public language, passed to another person, and then internally deciphered (Harris 1987).

1. It's about *languaging*.

Languaging is "activity in which wordings play a part" (Cowley and Kuhle 2020). Languaging is sometimes done for its own sake and more often is done as part of some other activity. In taking a language stance (following Dennett's [1989] notion of adopting an *intentional stance*), we treat virtual objects as real entities. Many times, in the midst of a conversation, we don't attend explicitly to what someone says or how they say it. More often than not we just respond. But when we respond to others *as if* they employ what is referred to in folk linguistics as a "language," we adopt a language stance. Again, this is analogous to Dennett's concept of the intentional stance. We adopt an intentional stance when it has greater predictive-explanatory power than other stances (e.g. a design stance). Often, we do this unaware; it's habitual [7].

But on occasion, we *do* think consciously about these things. When I reflect on why my spouse had a particular edge to her voice or why my boss used an odd phrase in his evaluation, I "adopt" a stance by which I treat the phonetic act as producing a bit of

---

[7] Thanks to an anonymous reviewer for pressing me to clarify this point.

language [8]. It's not a mere sequence of noises but rather coherent speech we hear. But what we call "words" or "sentences" are virtual objects, existing as much as pictures on a television screen. We languaging agents are capable of doing this because we are reared in literate cultures and thus have a range of concepts by which to understand bits of languaging activity as consisting of words and sentences.

2. It's about *interactivity* [9].

Languaging is a whole-body activity that takes place on multiple timescales. When we talk, obviously move our mouths and lips, but we also gesture, gesticulate, adjust our posture, and mime certain actions. Languaging involves the whole body; we respond to each other with our whole bodies. I show my disinterest in a conversation, for example by looking at my watch frequently; I haven't *said* anything about being disinterested but my actions communicate it as effectively as if I were to say "this conversation bores me." Additionally, languaging involves interactions at a multiplicity of time scales. At the smallest of levels, we respond to one another on the order of milliseconds: matching pitch or rubbing one's face (van Baaren *et al.* 2004). This happens quickly and outside our awareness. But languaging also happens on the order of biological and cultural evolutionary time scales. We are able to engage in languaging in the ways that we do because of these evolutionary pressures. The shift from quadrupedal movement to bipedal, for example, allowed our ancestors to rely more on vision than smell (cf. Gallagher 2005). This was a nomologically necessary (but insufficient) change to having our vocal tracts with their unique muscular control. A process that takes place on the order of tens of millenia informs how I'm able to manifest my power of languaging. Additionally, symbolic communication systems are cultural products, passed on from one generation to the next. These systems shape how we're able to enact our languaging capacities. I communicate as I do because I'm a speaker of American English at a particular place and time. The evolution of American English and its dialects takes place on the scale of centuries and decades, which likewise informs my languaging capacities.

3. It's about *ecology*.

There is no languaging in isolation. It's always and already embedded in some context. Context includes (but isn't limited to) physical space, social space, cultural context, temporal context, and the preceding bits of interaction. One need only reflect to see how the surrounding environment shapes any kind of languaging: in conversation with a friend, I recall previous conversations. I might talk about current events or refer to an object that is present to both of us. Languaging, then, is something that can't happen without a context in which the behavior takes place (cf. Järvilehto 1998, 2009).

4. It's about *emergence*.

Languaging is, fundamentally, an activity that depends on interactions between agents and environments. Utterances aren't preplanned "in the head" but rather unfold in the context of interaction. Languaging processes *emerge* from interaction and aren't reducible to their component parts (cf. Trasmundi and Steffensen 2016). The emphasis on emergence forestalls attempts to downplay the genuine interactive and embodied nature of languaging by prohibiting localization of non-local but relevant factors through use of internal representations. That's all to say, that any token instance of languaging

---

[8] "Adopt" is in scare quotes here since we don't consciously adopt this stance when listening to speakers of our native tongue. If we "adopt" a language stance, we do it as a matter of habit rather than as a conscious choice.

[9] For an excellent overview of the concept of interactivity, see Gahrn-Andersen *et al.* (2019)

___

depends on a variety of forces that, working in concert, enable successful communication.

There is more to say. For instance, even within DLA, we find important theoretical differences. Harris's integrationism, Linell's dialogism, and the Denmark school's distributed language approach ('DDLA') agree on the broad strokes given above but disagree on particulars (cf. Steffensen 2015 and Linell 2015 for a fruitful comparison of dialogism and DDLA). But DLA, at its heart, is an approach that has philosophical roots in non-Cartesian philosophical traditions, including (among others) the phenomenological tradition, the later Wittgenstein, and process philosophy. It rejects reification of linguistic entities and is steadfastly committed to the 4E paradigm within contemporary cognitive science. There are, of course, many philosophical routes to DLA. Gahrn-Andersen (2019), for example, draws on the Heideggerian tradition in his work. Cuffari (2012) likewise draws on the phenomenological tradition. Kravchenko's (2011) insights grow from Maturana. Lassiter (2016) connects DLA to an Aristotelian framework.

3. Biosemiotics

This covers a few central themes of biosemiotics. Much of this will be familiar to readers, but the details are needed. Remember that one of the desiderata is that powers can satisfy the functional role of codes. To get clear on the functional role of codes, we need to go through the major concepts of biosemiotics to locate codes in their theoretical framework.

The *semiotics* part of "biosemiotics" trades in sign production and consumption. The example at the start of this paper — that of a suitor and a prophet trying to read into the sign of two eagles tearing each other apart — is as fine an example as any of what's involved with semiotic processes. Following Peirce, there are three components to this sign: the sign-vehicle, the interpretant, and the object [10]. The sign-vehicle is that aspect of a sign that does the "pointing." It's what signifies the object. A vehicle signifies an object for an interpretant.

The way in which a sign-vehicle can point to another object depends on what sort of sign is being deployed. Icons point by virtue of similarity between the vehicle and the object (to an interpretant, of course). Indexes signify because of some kind of indicating relationship between the vehicle and an object. For example, smoke is an index signifying fire; a cat's paw print in the snow on my lawn is an index to a cat's having been on my laws. Symbols mean what they do in virtue of a conventional relationship between vehicles and objects. A stop sign signifies that the driver should stop; it does this in virtue of a conventional relationship between the sign and a social norm that requires stopping.

Treating signification as a three-place relation opens up a natural connection with the work of biologists like Jakob von Uexküll (1934/2010). Von Uexküll's development of the notion of an *Umwelt* is nearly tailor-made for Peircean semiotics. An *Umwelt* is best thought of as an organism's lifeworld, the space of significance and action. An example from von Uexküll is the humble tick. It has few sensory receptors, including abilities to detect butyric acid and to detect warmth. When the tick senses the presence of butyric acid, which is given off by mammals, it falls from a tree branch (or releases its hold on a blade of grass). If it has landed successfully, it will move in the direction of warmth,

___

[10] Cf. Collected Papers 2.227. An alternative view is that of Saussure (1916/2000). He proposes that signification is a two-place relation between the vehicle and the object.

presumably emanating from the animal. Once it can burrow no more, it pierces the skin of its prey and gorges on its blood.

Nature is gross, but this example tells us about the tick's *Umwelt*. It is limited, consisting of a handful of detectors. Butyric acid and warmth are meaningful to the tick, and its world is constituted by what is meaningful for the tick and nothing else. The world of the tick is not given by means of a God's-eye view or a photographic rendering of the scene.

The relationship with Peirce's semiotic scheme is clear. Butyric acid is a sign-vehicle to the tick (i.e. the interpretant), signifying the presence of prey (i.e. the object). The relationship between Peirce's semiotics and von Uexküll's biology lies in the meaningfulness of vehicles to interpretants. For von Uexküll, animals live in meaningful worlds, and the contents of those worlds signify what bears good or ill for those animals. The vervet monkey's alarm calls signify the presence of predators; the presence of a particular chemical signifies that an area has been explored for the slime mold.

Despite the appearance of overlap between Peircean semiotics and Uexküllian biology, there's an important difference. Peirce argues that signs determine their interpretants but his view on what constitutes an interpretant isn't restricted to organisms. In his early work, Peirce describes the interpretant as an idea arising from the vehicle-object relation (cf. Atkin 2010). He later describes the interpretant as a sign of the first sign (Eco 1976). Elsewhere, he writes that the act of attention can be an interpretant (Short 1996). In any case, it's clear that the notion of an interpretant isn't restricted to organisms. Or at least, it's not primarily defined in terms of organisms, even if organisms realize the ideas or signs in some way.

Pivoting from Peircean semiotics to biosemiotics requires a new way of identifying interpretants. For biosemiotics, interpretants are distinguished by the biological sciences. Understanding interpretants in this way, as biosemioticians like von Uexküll, Sebeok, Hoffmeyer, and Wheeler do, represents a break with Peirce but a fruitful synthesis between semiotics and biology. Note that the sign still determines the interpretant; it's just that the interpretant is understood in explicitly biological terms.

A recent titan of biosemiotics, Marcello Barbieri (2008), has argued that biosemiotics, in order to develop into a robust scientific discipline, must adopt a *code model*[11]. The idea is straightforward. The sign-object-interpretant relation is fleshed out in terms of a code relationship between vehicle and the object. This relationship between signs and what they signify may be natural — as when a fever is a sign of an infection — or conventional. The code of our DNA is a natural one; the code of street signs is conventional. In fact, for Barbieri, the triadic relationship that's necessary for biosemiotics to become a robust science is to map the vehicle-object-interpretant relation onto the genome-phenotype-ribotype relation. The sign is the genotype, the "meaning" is the phenotype, and the codemaker is the ribotype, a "a system of molecular machines based on RNAs" (Barbieri 2008: 26).

Barbieri distinguishes between a semiotics of *interpretation* and a semiotics of *coding*. A semiotics of interpretation, which we might associate primarily with Peirce, holds that the vehicle-object relation holds in virtue of the interpretant understanding the vehicle to signify the object. That is to say, the signification relation between the sign and the signified is grounded in interpretation of the sign by the interpretant[12]. A semiotics of

---

[11] Talk of "codes" is ubiquitous in biosemiotics. Hoffmeyer (1996), for instance, talks about "code duality". So do Sebeok and Kull. Though not typically claimed as a biosemiotician, Lotman (1990) freely uses the language of "codes".

[12] The analogue for this in contemporary analytic philosophy of mind and language is that words have *derived* content. They mean what they mean in virtue of an external entity imbuing them with meaning. In

coding, by contrast, holds that the triadic relation is among the sign, meaning, and code. "Code" is defined as a bridge between the domains of signs and meanings. Further, codes imply the existence of a codemaker. Unlike Paley's Watchmaker God, the codemaker needn't be conscious that it is creating a code. It could, as a matter of its ordinary functioning, create the mapping between the sign and the meaning. We find that this is what happens with the ribotype in the cell: it creates a code between genotype and phenotype.

On a semiotics of interpretation, a sign signifies its object in virtue of some action on the part of the interpretant. This red, octagonal sign means "stop" because we drivers interpret it as meaning "stop". On a semiotics of coding, a sign signifies its object in virtue of the codemaker's creating a code. This red, octagonal sign means "stop" because it encodes a relationship between a sign and an action. The difference hinges on what grounds the sign-relation. For a semiotics of interpretation, it is the *consumers* that ground the relation. When asking why *this* means *that*, the answer bottoms out in those consuming the sign. By contrast, for a semiotics of code it is in the *producers* where the answer bottoms out. *This* means *that* because something's functioning — ribotypes on Barbieri's account — make it so.

Barbieri argues that a scientific biosemiotics is a coding biosemiotics. Why? That the cell is interpretable as a semiotic system is a foundational theoretical commitment for biosemiotics. A coding semiotic relationship in the cell is necessary and sufficient for the cell to be understood as a semiotic system. It's necessary because the only other alternative (Barbieri argues) is an interpretation model. An interpretation model applied to cells stretches the concept of 'interpretation' to the point of breaking; mathematical functions might be understood as 'interpreting' the elements in their domain to 'mean' the elements in their range. Even more worrisome for biosemiotics, if interpretation is understood this broadly, then *everything* interprets and *everything* is an instance of semiosis. This means furthermore that there is no *bio*semiosis. Why? A foundational premise of biosemiosis is that metabolic and semiotic processes are co-extensive. If there are semiotic processes that are not coextensive with metabolic ones, then there is no distinct biosemiotics [13].

Given that coding is a foundational concept for Barbieri's vision of biosemiotics, as we have seen in the preceding discussion, it is worthwhile to inquire about its functional role in the overall theory. Codes are needed, Barbieri tells us, to "bridge" the sign with the meaning for the interpretant. But there's more: we're told that, while codes require a codemaker, the codemaker needn't be conscious that it's creating an encoding relation. Codes, then, are reifications of "bridges" between signs and meanings that are manufactured by codemakers. Barbieri's work gives us the two requirements for the functional role of codes and coding:

> Bridging: codes connect signs to meanings
> Codemaking: codes are created by codemakers, which may or may not be aware that they are creating a code; codes do not emerge from nothing

A quick word about Codemaking. This is a safety rail requirement: it ensures that *some* naturalistic story can be told about codes. The details of this naturalistic story are wide open. For example, *realism* about codes entails that codes be thought of as objects as real

---

this case, it's typically held that *thoughts* have non-derived meaning and words have meaning in virtue of their being "given" meaning — or interpreted as meaningful — by thoughts.

[13] This is Barbieri's argument. One could argue, of course, that there is something special about biosemiotics that marks it off from other kinds of semiotic processes of non-living things. Thus, biosemiotics would be a branch of pansemiotics.

as lizards, lakes, and livers. They're open to investigation as part of the furniture of the world. *Antirealism* about codes entails that codes don't really exist but it's useful to think about them as existing. In this case, investigation into codes would tell us more about human psychology than it would about connections among entities in the world. Either way, Codemaking requires that the empirical sciences have something to say about codes.

4. Biosemiotics and DLA coming apart

So far, we've considered Barbieri's biosemiotics, which focuses on cells. Cells don't obviously perform speech acts or engage in languaging. So what's the connection between Barbieri's biosemiotics and DLA[14]? Biosemiotics, at least when looking at human consumption and production of signs, is happy to talk about the relationship as one of "encoding" and of signs referring to internal representations (cf. Beni 2017; Lorenzo, Rubiera 2019). DLA, however, is loath to posit internal representations or think of the relationship between signs and signifieds as one of encoding.

The obstacle to a reconciliation between biosemiotics — or at least a biosemiotics as Barbieri imagines it — and DLA is whether DLA is willing to take on representations and encodings or biosemiotics is willing to ditch them.

Here is the argument:
1. If the coding concept in biosemiotics entails mental representations, then biosemiotics is inconsistent with DLA
2. The coding concept in biosemiotics entails mental representations.
3. Therefore, biosemiotics is inconsistent with DLA.

We've already seen evidence for the first premise. Suppose that the concept of coding in biosemiotics entails mental representations, then since biosemiotics is committed to codes it's inconsistent with DLA, since DLA actively excludes mental representations from its theoretical vocabulary.

So the nub is the second premise: why think that the coding concept in biosemiotics entails mental representations?

Consider a non-biological example of coding[15]. Those titans of metamathematics, Gödel and Turing, offer exemplars of coding without necessarily referring to semantic content: a string of numbers (or characters or whatever) is transformed into another string in a systematic way[16]. Gödel, for example, used a scheme by which arithmetic proofs were represented by unique numbers. Now the scheme by which the string of numbers encodes a proof is a matter of convention: subsequent work in metamathematics shows that there are plenty of ways to encode proofs in strings of numbers. But what's crucial to the concept of encoding is that the conventional way by which the vehicle encodes the object is systematic in the sense that it can be worked

---

[14] See Kravchenko (2020) for another critique of code-biosemiotics through the lens of languaging.

[15] We begin with non-biological examples to avoid begging the question: we won't be attempting to get clear on the code-concept by appeal to a 'genetic code' because that's the very concept we're trying to get some clarity on.

[16] There are more books on this issue in mathematical logic than you could shake a stick at. But an excellent introduction is Nagel and Newman (2001).

out. The encoding number is the sign; the proof is the object; and the interpretant is the mathematician doing the encoding [17].

What can we learn from this case? First, it reinforces what Barbieri says about codes: there is a sign, a meaning, and "bridge" of sorts between them. Second, while the bridge may not *require* an interpreter, to a suitable interpreter the sign *represents* the meaning. In the metamathematics case, a student may not understand how a string of numbers represents a proof for '1+1=2' but the seasoned logician can. So, while the student may not have the tools for understanding how the coding relation works, there is nonetheless one there, one to which appropriately trained individuals are able to grasp how the sign "points to" the meaning.

How might we apply this to mind and language? If the relationship between signs and objects is one of coding, then a broadly Lockean view of language holds between words and meanings: words signify mental representations (Ott 2004). For example, a sentence like "The wine stained the carpet" means *the wine stained the carpet* to interpretants. The sentence signifies a state of affairs, which is internally represented by speakers and hearers. Code-biosemiotics leads to a view of language that is antithetical to DLA. It has all the resources to develop a Lockean view of language in which verbal utterances are outward signs of internal meanings, a point likewise argued by Kravchenko (2020). Biosemiotics, as conceived by Barbieri, may be novel in biology, but it embraces a view of mind and language that's at least as old as the English Civil War.

The impasse is avoidable. There are at least two options.

The first divides semiosis of cells from semiosis of persons. Parts of the cell might encode meanings, it needn't be the case that humans encode meanings as representations. Instead, the biosemiotician might argue that *persons* interpret while *cells* code — in fact this is just the sort of move we see in Barbieri (2020), where he develops his "semantic theory of language" [18]. What is the cost of this maneuver? It generates a dualist biosemiotics: code-biosemiotics for cells and interpretation-biosemiotics for persons. While a theoretically live option it seems a bit odd from the biosemiotic perspective: the semiotic relationship would differ depending on whether we're talking about a person or a person-part. The bigger puzzle entailed by this dualist move involves the scaling up of person-part-semiosis to person-semiosis: when does the semiotic relation *stop* being one of coding and *start* being one of interpretation? Plenty of stories can be told but most seem fairly *ad hoc*. So, the dualist option is a theoretically live one but seems to offer more difficulties than solutions.

The second option is DLA abandoning its resistance to "code"-talk. What does DLA risk in talking about vehicles "encoding" meaning? In a word: everything. One of the principle claims of DLA is that languaging activity is distributed, which is to say that our concept of 'meaning' can't be something that's encodable. Why? It's because *encoding* is a species of *representing*. Representing is a binary or triadic relation in which *a* represents *A* (to some interpreter, if understood as triadic). Ways that *a* can represent *A* are legion: it might be by resemblance or *a* might be an index for *A*. What's important is that *a*'s represent *A*'s as a matter of social or cultural convention. Words representing meanings, whatever they happen to be, are not theoretical entities within most work in DLA. Lockean models of meaning posit entities that are not within the domain of discourse for DLA.

---

[17] The coding is an acceptable encoding provided the decoding is doable by means of functions that a simple computer can do. That's to say that the number has to be Turing computable, which is equivalent to the notion that the proof can be produced from the encoding number by means of primitive recursive functions. Cf. Kleene 1952.

[18] This was previously alluded to: that Barbieri has left biosemiotics for code biology. Thanks to an anonymous reviewer for bringing this to my attention.

So, if we're to unite the fields of DLA and biosemiotics, the latter will have to give up its talk of codes, provided "code" is meant in its typical way as representational. But, as we'll see, a neo-Aristotelian metaphysics is able to offer a theoretical posit satisfying the role of codes in biosemiotics while abandoning the representational relationship between languaging and people.

5. Satisfying the desiderata: How causal powers realism bridges DLA and biosemiotics

Let's begin by recalling the desiderata with which the paper began. A metaphysic that could synthesize biosemiotics and DLA:

1. has the resources for describing language as a distributed phenomenon.
2. is amenable to the tripartite relationship among signs, objects, and interpretants that is characteristic of Peircean semiotics. In particular, this theory would have to have the conceptual resources to express these relationships.
3. has theoretical posits which satisfy the functional role of codes in biosemiotic theory.

Causal powers realism satisfies all three desiderata. The first has been done elsewhere (Lassiter 2016, 2019).

The second desideratum is satisfied by reformulating the concepts of sign-vehicles, objects, and interpretants using the concepts of causal powers realism. This means taking casual powers realism as a background ontology by which to interpret the ontology of signs. Rather than using, say, Peirce's metaphysics or materialism as background ontologies, we use the neo-Aristotelian-inspired causal powers realism.

Consider first, sign-vehicles. Vehicles have a range of powers. Stop signs, for instance, have the power to get hot in the sun or to be blown over in a strong wind. But signs also have powers to signify objects to interpretants. Our stop sign can not only get hot in the sun, but it can also signify to a driver that the driver ought to stop. It gets this power from the power of the object to be signified and also from the power of the interpretant to understand that the sign signifies the object.

Objects likewise have a range of powers. To continue with the above example, the object signified by the stop sign is that the approaching driver ought to stop. Set aside the vexing question of material realizations of norms and proceed with the assumption that norms are the kinds of things that can be signified by signs [19]. Norms, that is, have powers. For example, it's a norm in many Western cultures for brides to wear white on their wedding day. This norm exerts causal influence: many brides wear white *because* that's the norm. The way in which the norm exerts causal influence is different from how billiard balls or blasting powder exert causal influence, of course, but they influence nonetheless. Aside from these powers, norms have another power: the power to be signified by signs to interpretants. That drivers ought to stop at a stop sign is a norm that not only compels drivers to stop but is also capable of being signified.

---

[19] It's possible to keep the heavy metaphysical commitments at bay by adopting a naive view. Sometimes people follow norms and sometimes they don't. Some norms are mandatory and some aren't. Some are moral, others epistemic, and others aesthetic. Some are cultural and some are social. Norms have all these properties. It may not be clear just what the realizers of norms *are*: that's the tricky metaphysical question. But we can still talk about norms as entities with powers and that these are independent of their realizers. For a brief but informative introduction for naturalizing epistemic norms, see Rysiew (2021). Thanks to an anonymous reviewer for suggesting this point.

Finally, interpretants have a range of powers. Humans, for example, have all manner of powers. And so do rabbits, trout, cicadas, ivy, and slime mold. Among these organisms' powers are powers to be determined by signs signifying objects. In other words, these organisms all have powers to grasp signs as signifying objects. All of these organisms respond to signs in their *Umwelten* as signifying objects. They are sensitive to what signifies what in their worlds.

This completes the argument that causal powers realism satisfies the second desideratum: how vehicles signify objects to interpretants can be described in terms of causal powers. An important feature is the power to signify: signs have powers to signify objects to interpretants; objects have powers to be signified; interpretants have powers to be sensitive to signs signifying objects. What does it mean to say that vehicles "ignify" their objects? A rough analogy would be to think about signification as like Frege's notion of sense. Frege separated terms' sense and reference. While a term's referent is the object it picks out, its sense is the "mode of presentation" of that object. "Student of Plato" and "teacher of Alexander the Great both refer to Aristotle but do so with different modes of presentation. For Frege, modes of presentation are not concepts but rather Platonic senses to be grasped by speakers. The sense of 'student of Plato' was not possessed by any individual mind but rather accessible to any competent speaker of the language. Ancient and medieval theories of signification do not so neatly pull apart concepts and objects. Aristotle, for instance, holds in *De Interpretatione* that words name things by signifying concepts. In early medieval semiotics, Aristotelians and Augustinians disagreed about what terms signify. The Aristotelians held that words *name* things and *signify* mental concepts. The Augustinians held that words *signify* things *by means of* mental concepts. Signification, then, involves elements of sense and reference, but it is a referential activity indexed to concepts in some way.

The third desideratum is that causal powers realism endorses some ontological entity that is capable of performing the same functional role as codes. Recall that the functional roles of codes are:

> Bridging: codes function to connect signs to meanings
> Codemaking: codes function as they do because they are created by codemakers, which may or may not be aware that they are creating a code.

Powers are capable of satisfying both of these roles. Consider Bridging first. Recall that powers manifest their effects in conjunction with manifestation partners. A stop sign signifies to the driver that they ought to stop. The "bridge" in this case is between the sign and the norm; the sign encodes a norm. But this "bridge" can also be secured by the sign's power to signify an object to an interpretant. It is because the sign has the power to signify the object and the object has the power to be signified that the interpretant can grasp that the sign signifies the object. The "bridge" in this case isn't a matter of a sign acting as a code for its object. Rather, the "bridge" is the sign's power to signify conjoined with the object's power to be signified.

Now consider Codemaking. The central idea of this requirement is that there is something — the codemaker — that's causally responsible for the sign signifying its object, *and* that the codemaker's functioning is open to empirical investigation. Powers satisfy this constraint but not by substituting a codemaker with some other entity. Instead of asking about an entity that creates the "bridge" between vehicles and objects, a powers ontology instead asks about the kinds of powers that enable vehicles to signify their objects to interpretants. For instance, a stop sign signifies that a driver ought to stop because of the powers of drivers to grasp the meaning of the sign. But what accounts for *that*? In a word, socio-cultural collectives establish the meaning by

convention: the relationship between the sign and its meaning is an emergent product of coordination among many individuals [20]. And all of this is open to empirical investigation.

With this, all three desiderata are satisfied. Causal powers realism (1) has the resources for describing language as a distributed phenomenon; (2) can express the tripartite relationship among signs, objects, and interpretants; and (3) satisfies the functional role of codes in biosemiotic theory.

6. Resulting view

At this point, readers might reasonably wonder, "why worry so much about the ontology for biosemiotics?" Here's one implication. Adopting causal powers realism as an ontology for biosemiotics throws light on the concept of symbols. In particular, it enables expression of Peirce's insight about the nature of symbolic reference without having to adopt Peirce's labyrinthine metaphysics.

In introducing the notion of a symbol, we glossed over an ambiguity. A symbol, recall, is a sign whose signifying relationship is conventional. But a symbol can be a *type* or a *token*. When one says that high heels or crucifixes are symbols, the symbol-type is being used. But when referring to *this* crucifix, then the symbol-token is used. For Peirce, symbols are types *only*. The relationship between wearing a crucifix about one's neck and one's religious beliefs is a relationship among types; but *this priest's* wearing a crucifix is an *indexical* relation to his religious beliefs. The crucifix-token signifies the religious beliefs to an interpretant in virtue of the relationship holding among the crucifix-symbol. The tokens signify as they do because of the corresponding types. Peirce notes that symbols can only act through existing replicas, i.e. token instances of a sign [21].

In terms of powers, a stop sign has the power to signify its object — that the driver should stop — to an interpretant. We mentioned above that the stop sign has the power to do this in virtue of groups of agents investing the stop sign with that meaning. The sign has the power to signify a norm to a group; the norm has the power to be signified by a sign to a group; the group has the power of understanding that the sign signifies the norm.[22] This is a Peircean symbol since it involves only general cases.

But now let's move on to the particular case. When I'm driving my car, a particular stop sign signifies to me that I ought to stop. In this case, the particular sign is acting as an index and not a symbol. But, the particular sign has the signifying power it has *in virtue of* the symbol. That is to say that the particular sign is capable of signifying a norm because in general stops signs signify to drivers that they ought to stop.

Further, the event-type *that people stop at the sign* is likewise a symbol — a higher-order symbol. It signifies that the sign-stopping-people were reared in a particular sort of culture to individuals with the know-how to grasp this, people like anthropologists. And *my stopping at the stop sign* is a higher-order index, signifying to interpretants that I was reared in a particular culture.

---

[20] But causal powers realism is capable of handling cases in which the relationship between sign and object is the product of individual actions and choices: instead of the connection being produced in virtue of the powers of a spatially and temporally dispersed group, it is instead produced by a single individual's powers.

[21] Collected papers 2.249. Deacon builds on this distinction in his (1997).

[22] An open question is whether the group grasps that the sign signifies the norm *or* that the sign signifies the norm *to them*.

Causal powers realism ascribes powers to the event-type *that people stop at stop signs* [23]. It has the power to signify that sign-stopping-people were reared in a particular culture to interpretants. Being reared in a particular culture likewise has the power to be signified to interpretants by a symbol. And interpretants have the power to grasp that that symbol signifies that object.

One upshot is that causal powers realism has the conceptual resources necessary to express Peirce's insights about the relationship between symbols and indexes but without needing to adopt the Peircean metaphysics. Details about particular causal powers are identified through investigation by the relevant empirical sciences. So Peirce's insights about the nature of symbols and indexes are ultimately open to naturalization by means of the sciences. Psychologists, biologists, sociologists, linguists, and anthropologists will fill in the details for these powers. In this way, Barbieri's aim of naturalizing biosemiotics is preserved, even if it looks a bit different.

7. Conclusion

In this paper, I argued that causal powers realism provides a suitable background ontology for synthesizing biosemiotics and DLA. What's the upshot of such a synthesis? Why should anyone care if such a synthesis can even take place?

Biosemiotics as Barbieri imagines it is reductive. Life and semiosis are co-extensive because the smallest bits of life are swept up in semiotic relations. Since this applies to the smallest bits of life, the argument goes, it applies to larger bits too. So, what grounds semiotic relations at the level of humans is the fact that cells are semiotic — or rather biosemiotic — entities. I think that trying to ground semiotic relations for utterances and hearers in cells is a mistake. Such an attempt is analogous to looking for the neural realizers of consciousness. It engenders an explanatory gap. That my cells are biosemiotic entities doesn't say anything about my own semiotic capacities.

By attempting this synthesis, we can get the best of both DLA and biosemiotics without generating an explanatory gap or appealing to worrisome internal representations. Synthesizing DLA and biosemiotics offers a suite of conceptual resources to ground languaging as an embodied and embedded activity [24].

References

Atkin, Albert (2013), «Peirce's Theory of Signs», in *The Stanford Encyclopedia of Philosophy* Edward N. Zalta (ed.), URL = <https://plato.stanford.edu/archives/sum2013/entries/peirce-semiotics/>.

Barbieri, Marcello (2008), «The code model of semiosis: the first steps toward a scientific biosemiotics», in *The American Journal of Semiotics*, 24, n. 1/3, pp. 23-37.

---

[23] Suspend judgment about the metaphysics of event-types and focus on the coherence of talking about event-types as having powers independently of their realizers.

[24] Thanks to two anonymous reviewers for helpful feedback as well as to Stephen Cowley for the invitation to submit and conversation about these and related issues. Finally, thanks to Garland Rossman, whose discussions and support have been valuable beyond measure.

Barbieri, Marcello (2010), «On the origin of language: A bridge between biolinguistics and biosemiotics», in *Biosemiotics*, 3, pp. 201–223.

Barbieri, Marcello (2010), «Codepoiesis: The deep logic of life», in *Biosemiotics*, 5, pp. 297–299.

Bateson, Gregory (1972), *Steps to an ecology of mind*, Ballantine, New York.

Bateson, Gregory (1979), *Mind and nature: A necessary unity*, Bantam, New York.

Beni, Majid Davood (2017), «The Code Model of Biosemiotics and the Fate of the Structuralist Theory of Mental Representation», in *Biosemiotics*, 10, pp. 99–107.

Cowley, Stephen J (2011), «Taking a language stance», in *Ecological Psychology*, 23, n. 3, pp. 185-209.

Cowley, Stephen J, Kuhle Anneliese (2020), «The rise of languaging», in *Biosystems*, 198, pp. 104-264.

Cuffari, Elena Clare (2012), «Gestural sense-making: hand gestures as intersubjective linguistic enactments», *Phenomenology and the Cognitive Sciences*, n. 11, pp. 599–622.

de Saussure, Ferdinand (1916), *A Course in General Linguistics*, Eng. Trans. by R. Harris, Open Court Publishing, New York 2000.

Deacon, Terrence (1997), *The symbolic species: The co-evolution of language and the brain*, WW Norton & Company, New York.

Dennett, Daniel (1989), *The Intentional Stance*, MIT press, Cambridge.

Gahrn-Andersen, Rasmus (2019), «But language too is material!», in *Phenomenology and the Cognitive Sciences*, 18, pp. 169–183.

Gahrn-Andersen, Rasmus, *et al.* (2019), «Interactivity: Why, What and How?», in *RASK–International journal of language and communication*, 50, pp. 113-136.

Gallagher, Shaun (2005), *How the Body Shapes the Mind*, Oxford University Press, New York.

Harris, Roy (1987), *The Language Machine*, Duckworth, London.

Harvey, Matthew, Gahrn-Andersen, Rasmus, Steffensen, Sune Vork (2016), «Interactivity and enaction in human cognition», in *Constructivist Foundations*, 11, pp. 602–613.

Heil, John (2003), *From an ontological point of view*, Oxford University Press, Oxford.

Hoffmeyer, Jesper (1996), *Signs of Meaning in the Universe*, Indiana University Press, Indianapolis.

Husserl, Edmund (1948), *Experience and Judgment*, Eng. Trans. by J. Spencer Churchill and K. Ameriks, Northwestern University Press, Chicago 1973.

Järvilehto, Timo (1998), «The theory of the organism-environment system: I. Description of the theory», in *Integrative Physiological and Behavioral Science*, 33, pp. 321–334.

Järvilehto, Timo (2009), «The Theory of the Organism-Environment System as a Basis of Experimental Work in Psychology», in *Ecological Psychology*, 21, pp. 112-120.

Jaworski, William (2016), *Structure and the metaphysics of mind: How hylomorphism solves the mind-body problem*, Oxford University Press, Oxford.

Kravchenko, Alexander V. (2011), «How Humberto Maturana's biology of cognition can revive the language sciences», in *Constructivist Foundations*, 6, n. 3, pp. 352-362.

Kravchenko Alexander V. (2020), «A critique of Barbieri's code biology», in *Constructivist Foundations*, 15, n. 2, pp. 122–134.

Lassiter, Charles (2016), «Aristotle and distributed language: capacity, matter, structure, and languaging», in *Language Sciences*, 53, pp. 8-20.

Lassiter, Charles (2019), «Language and simplexity: A powers view» in *Language Sciences*, 71, pp. 27-37.

Lassiter, Charles, Vukov, Joseph (2021), «In search of an ontology for 4E theories: from new mechanism to causal powers realism», in *Synthese* (https://doi.org/10.1007/s11229-021-03225-1).

Linell, Per (2015), «Dialogism and the Distributed Language Approach: a rejoinder to Steffensen», in *Language Sciences*, 50, pp. 120-126.

Lotman, Yuri (1990), *Universe of the Mind: A Semiotic Theory of Culture*, I.B. Taurus & Co., Ltd, London.

Lorenzo, Guillermo, Emilio, Rubiera (2019), «On Iconic-Discursive Representations: Do they Bring us Closer to a Humean Representational Mind?», in *Biosemiotics*, 12, pp. 423–439.

Nagel, Ernest, Newman James R. (2001), *Gödel's Proof*, ed. by Douglas R. Hofstadter, New York University Press, New York.

Ott, Walter (2004), *Locke's Philosophy of Language*, Cambridge University Press, New York.

Quine, Willard V. (1948), «On what there is», in *The Review of Metaphysics*, pp. 21-38.

Rysiew, Patrick (2021), «Naturalism in Epistemology», in *The Stanford Encyclopedia of Philosophy*, ed. by Edward N. Zalta, Fall 2021 Edition, URL = <https://plato.stanford.edu/archives/fall2021/entries/epistemology-naturalized/>.

Sebeok, Thomas (1979), *The sign and its masters*, University of Texas Press, Austin.

Sebeok, Thomas (1986), «Towards a natural history of language», in *Semiotica*, 65, pp. 343-358.

Short, Thomas L. (1996), «Interpreting Peirce's interpretant: A response to Lalor, Liszka, and Meyers», in *Transactions of the Charles S. Peirce Society*, 32, n. 4, pp. 488-541.

Steffensen, Sune Vork (2015), «Distributed Language and Dialogism: notes on non-locality, sense-making and interactivity», in *Language Sciences*, 50, pp. 105-119.

Trasmundi, Sarah Bro, Steffensen, Sune Vork (2016), «Meaning emergence in the ecology of dialogical systems», in *Psychology of Language and Communication*, 20, n. 2, pp. 154-181.

Trasmundi, Sarah Bro, Cowley, Stephen J. (2020), «Reading: how readers beget imagining», in *Frontiers in Psychology*, 11, pp. 23-35. DOI=10.3389/fpsyg.2020.531682

Van Baaren, Rick B., *et al.* (2004), «Mimicry and prosocial behavior», in *Psychological Science*, 15, n. 1, pp. 71-74.

Vetter, Barbara (2018), «Perceiving Potentiality: A Metaphysics for Affordances», in *Topoi*, 39, pp. 1177–1191.

von Uexküll, Jakob (1934), *A Foray into the Worlds of Animals and Humans*, Translated by Joseph D. O'Neill, University of Minnesota Press, Minneapolis 2010.

Vukov, Joseph, Lassiter, Charles (2020), «How to power encultured minds», in *Synthese*, 197, pp. 3507–3534.

Wheeler, Wendy (2006), *The whole creature: Complexity, biosemiotics, and the evolution of culture*, Lawrence and Wishart, London.