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SCAFFOLDED MINDS AND THE EVOLUTION OF CONTENT IN SIGNALING PATHWAYS

Abstract. Hutto and Myin (2013) famously argue that basic minds are not contentful and content exists only as far as it is scaffolded with social and linguistic practices. This view, however, rests on a troublesome distinction between basic and scaffolded minds. Since Hutto and Myin have to account for language purely in terms of joint action guidance, there is no reason why simpler communication systems, such as cellular signaling pathways, should not give rise to scaffolded content as well. This conclusion remains valid even if one rejects the view of language as mediated through public symbols and embraces global antirepresentationalism. Content evolves spontaneously in complex regulatory systems, such as human, animal, and cellular communication.

Keywords: philosophy of cognitive science, content, Hutto and Myin, Hard Problem of Content, representation, cell signaling, the distributed view of language

Hutto and Myin (2013), henceforth "H&M", argue that the mind is not essentially contentful and basic minds are to be explained in terms of complex mind–environment couplings, with no commitment to representation talk at all. Content arises late in both phylogeny and ontogeny, they claim, only as far as it is scaffolded and supported with social and linguistic practices. This view is called *Radical Enactive (or Embodied) Cognition* (REC) or simply *radical enactivism*. The pivotal argument supporting REC is the existence of the Hard Problem of Content (HPC); according to HPC, naturalist theories of content fall short of giving a reductive account of how contents emerge in basic minds.

I will focus on one point that makes REC at least problematic: the distinction between basic and scaffolded minds. According to H&M, when the basic mind is extended through shared social practices and becomes capable of linguistic communication, it becomes scaffolded and capable of bringing about content. It is hard, however, to give a non-circular definition of the emergence of content through linguistic scaffolding, since language is traditionally thought to be essentially contentful. If linguistic practices

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reduce to guiding joint action, then H&M's concept of scaffolded content becomes far too broad and renders REC trivial.

The structure of the paper is as follows. First, I outline the HPC argument and how it supposedly affects Dretske's indicator semantics and Millikan's teleosemantics. Then I discuss H&M's account of language and the scaffolding of linguistic content. Whatever it is that makes language bring about content, I argue, it should also take place in animal communication and biological signaling pathways. In the third section, I analyze Harvey's (2015) proposal to substitute H&M's opaque yet contentful theory of language with the an antirepresentational variant of the distributed view of language. This bold maneuver solves the troublesome issue of the emergence of linguistic content by denying that linguistic activity is contentful at all. It does not save radical enactivism from a variant of what H&M call "the scope objection", however, since the notion of meaning potentials Harvey relies on turns out to be minimally contentful as well. I conclude by characterizing what a good defense of antirepresentationalism should look like.

1. The Hard Problem of Content Argument

The logical structure of the HPC argument can be summarized as follows (see also Korbak, 2015, pp. 126–127):

(T1) Ontological commitments in cognitive science must respect explanatory naturalism;
(T2) Linguistic activity is out of the scope of basic minds;
(T3) Having content implies having certain satisfaction conditions, which determine intension and extension (if it exists);
(T4) Every theory of content fails to respect either (T1), or (T2), or (T3);
(T5) Having content is constitutive for being a representation.

Note that (T3) mentions satisfaction conditions, which is a generalization of truth conditions. According to a classic Tarskian idea in formal semantics, conditions of satisfaction reduce to simple truth conditions (Davidson, 1967). There are, however, other types of satisfaction conditions, for instance for imperatives. A feasible argument should not, also, preclude using some sort of a non-standard semantics for positing content; e.g., Gauker (2011) explicates minimal perceptual content in terms of accuracy conditions over a perceptual similarity space.

(T1)–(T4) jointly imply that REC is true. However, what makes REC a viable hypothesis in cognitive science rather than a mere philosophical

curiosity is antirepresentationalism following from (T5). (T3), the only controversial premise in the argument, is supported by enumerating existing naturalist theories of content and showing that they all fail to give rise to satisfaction conditions.

A naturalist theory of content aims at reducing content to some ontologically simpler beings, be it natural law, information, or proper function. For instance, Dretske (1981) explicates the concept of indication (transmitting semantic information) as a lawful covariance of two physical states. Thus content is to be understood in terms of properties such as having an actual physical state and a number of possible physical states (with given probability distribution), covariance, as well as natural laws. H&M object that the covariance relation alone is not sufficient to give rise to satisfaction conditions. This characterization hardly does justice to Dretske's theory, since covariance is not all it takes to bring about content in Dretske's view; note that natural laws are intensional and the property of being in a given state non-controversially has truth conditions (*contra* H&M). Also, indicating is not observer-dependent (which would have rendered Dretske's account circular, Hutto & Myin, 2011, p. 70), but has a pretty precise and not content-involving definition in terms of conditional probability (Dretske, 1981).

H&M's critique of Millikan's (1989) teleosemantics also shows some gaps. H&M turn to the functional indeterminacy problem as laid down by Fodor (2008): the concept of proper function is too weak to give rise to fine-grained satisfaction conditions, for a description of some selection history is extensional and truth conditions should be intensional instead. Fodor is quite an unusual companion for a radical enactivist, though, and his argument seems to be committed to a highly questionable form of antidarwinism. As Block and Kitcher (2010) point out, if intensionality is to be understood as changing truth value under some substitutions of co-extensional terms, then there is also a *causal* indeterminacy problem that undermines modern science altogether. But it is hardly problematic at all: out of many co-extensional descriptions (causal or functional) scientists simply choose the most empirically interesting one.

I am not going to mount a detailed defense of either Dretske's or Millikan's account. I only wish to point out that H&M reject both accounts prematurely. This does not mean the accounts are not debatable or even false. Yet it shows that HPC is not as hard as H&M would like it to be.

2. REC, Language and the Emergence of Linguistic Content

It is sometimes argued (Harvey, 2015) that what REC lacks is a positive account of linguistic practices. H&M claim that linguistic content is safe from HPC and they "are not advancing Really Radical Enactive or Embodied Cognition as a thesis about the nature of all minds. Some cognitive activity—plausibly, that associated with and dependent upon the mastery of language—surely involves content" (Hutto & Myin, 2013, p. xviii). However, they offer little in the way of explanation of why the realm of linguistic activity should be privileged and how content emerged in the scaffolded minds of language users in the first place. Moreover, it is not even clear what exactly H&M mean when they talk about language. The following features seem relevant for them: (i) the function of language is communication in a social group, (ii) enabling and guiding joint action among many agents, and (iii) language use gives rise to certain norms that in turn bring about satisfaction conditions.

Alksnis (forthcoming) and Harvey (2015) suggest that H&M draw on Hutto's (2008) previous work on folk psychology, where he assumed a broadly classical Davidsonian propositional concept of language. According to this view, engagement in linguistic activity presupposes possessing propositional attitudes, which are contentful in virtue of their truth conditions. In other words, linguistic activity is inherently contentful. If that is so, the radical enactivist account of the emergence of content is not even false, it is circular. Instead of explaining why using language is contentful, it simply presupposes that it is.

Since H&M cannot rely on a traditional model, where language intentionality derives from the intentionality of thought, it is a matter of interpretive charity to drop the assumption that H&M embrace the traditional model. One thing for sure, what REC needs is a non-mental and content-free account of linguistic practices to show how linguistic practices give rise to genuine content. Such a theory of content—pioneered by late Wittgenstein—is indeed feasible, but has its consequences.

Let's assume then, for the sake of argument, that H&M do have a reliable, non-circular account of the emergence of content in scaffolded, linguistic minds. This is hardly an usual concept of human language, however. H&M, following Williams' (2010) characterization of Wittgenstein, describe representational use of language as requiring "a context . . . the exercise of techniques for going on in the same way, and shared sense of the obvious and the certain" (Hutto & Myin, 2013, p. 180). This view seems pretty amenable to an inverted version of what they call the scope objection: antirepresen-

tational explanations of simple cognitive phenomena are of limited value as they don't scale up (p. 45). This is because the problem with H&M's account of language practices is that it is indeed very weak and it probably *does* scale *down* more than H&M would want it to. Why should we think that it pertains only to elaborate human natural languages? Their characterization does not include syntactical properties traditionally taken to distinguish human language from animal communication, i.e., productivity, and duality of patterning (Hockett, 1960) and there is no reason to think these are crucial to the emergence of content. They mention displacement (pp. 40–41), i.e. referring to distant targets, but it only makes things worse as it can be argued to presuppose content as well.

Think of a meerkat guard alarming its companions that a hawk is approaching. This signal is clearly event-specific (if it were a mole snake, the signal and the expected reaction would be different), as well as action- and group-oriented. An alarm signal could also turn out to be false due to error or voluntary cheating. Actually, cheating, or giving dishonest signals, is a central problem in evolutionary signaling theory and remains amenable to strict game-theoretic explanations. Putting all these together, animal communication seems perfectly fit to a light-weight concept of language as a tool for joint action. It seems to neatly scale down even more: take honeybees' waggle-dancing, or leukocytes collectively detecting a pathogen in the body, or quorum-sensing in bacteria, or even simple cell signaling. Note that since H&M cannot presuppose minds or contents at this point (not to mention persons), *social* must be understood as *multi-agent*, which encompasses quite a lot of complex biological mechanisms.

The idea that genuine linguistic activity can be found as early in phylogeny as in cell signaling is not new and a viable theory can be found in Pattee (1969). This view is attractive, since it does not need a sophisticated account of spontaneous generation of an elaborate discourse; on the contrary, "highly evolved languages and measuring devices are only very specialized and largely arbitrary realizations of much simpler and more universal functional principles by which we should define languages and measurements" (Pattee, 1985, p. 26). According to Pattee, intracrine (within-cell) signaling arises in the cell as a hierarchical control system, whose function is to maintain the cell's internal milieu. The signaling system is thus constrained by its ecological niche; signals do not appear alone out of nowhere and do not have well-defined rules of use in the first place, but—through evolutionary optimization and self-organization—form complex signaling networks and it is only in the context of a larger network that a signal has a meaning. The emergence of signaling networks

is a bootstrapping process: it is triggered by environmental constraints and in the end the signals that gets transmitted are nothing but another useful constraint on the entire cell's dynamics. (A similar though more elaborate evolutionary game-theoretic account of the emergence and evolution of signaling systems can be found in Skyrms, 2010). It seems that key traits of H&M's minimal concept of language—action-guidance, strong context-sensitivity, and coordination of multi-agents system's dynamics—can be easily found even in intracrine signaling. Indeed, we have a group of agents and a set of signals (molecules) that affect each agent's behaviour in a reliable, well-defined, and receiver-specific way to keep the system coordinated.

Now whatever it is that makes human linguistic practices give rise to content should also give rise to content in waggle-dancing honeybees, quorum-sensing in bacteria, and hormones in one's endocrine system as they manifest the same lightweight language-like properties. (There are, of course, elaborate theories of how content emerges in such signaling networks, but at this point we do not even need one. Following H&M, we just assume language gives rise to genuine content). What is more, considering the pivotal role of intracrine signaling in biological regulation, it is non-controversially a precondition for metabolic activity and thus being alive in the first place. H&M do not even have to accept the deep continuity between mind and life thesis (Thompson, 2007) to be perplexed by this. As they do accept that the mind is essentially embodied and have to accept that this body is subject to biological regulation through elaborate language-like signaling systems, they also have to accept that the existence content is (at least) a precondition for being a mind. And this makes REC false or at most a very dissatisfying claim. (To be fair, H&M could argue that the biological necessity of signaling is not the metaphysical necessity they are interested in, or whether there is a possible world where living organisms get by without signaling and embody truly contentless minds. Thus, metaphysically, the mind might still not be essentially contentful. This is not an interesting claim for a naturalist philosopher, though).

Obviously, this is not what H&M want biological signaling to be:

> [W]e have reason to think that on-line sensory signals "carry information" in the covariance sense but not that they "pass on" meaningful or contentful messages. There is no naturally occurring contentful information that can be "used and fused" to form inner representations. Unless we assume that pre-existing contents exist to be received through sensory contact, the last thread of the analogy between basic cognitive systems and genuinely communicating systems breaks down at a crucial point. (Hutto & Myin, 2013, p. 70)

But on their own characterization, basic cognitive systems do genuinely communicate because they are alive, or nothing (not even H&M themselves) does. In other words, the distinction between basic minds and scaffolded minds is no longer a credible option when accounting for the emergence of content is concerned. What H&M could do is present a more robust view of language practices. This roughly describes Harvey's (2015) strategy.

3. H&M's Strengthened Strategy: The Distributed View of Language

Recall that H&M stress they are not defending RREC (the *Really* Radical Enactive Cognition thesis) as they claim "even the most radical of enactivists need not, and should not, deny the existence and importance of contentful and representationally based modes of thinking" (Hutto & Myin, 2013, p. 13). Harvey's (2015) move is precisely that: to defend RREC from the perspective of an antirepresentational variant of the distributed view of language (Cowley, 2011). Global antirepresentationalism is a bold and risky claim indeed. One may easily consider it self-refuting: if even plain sentences are meaningless, what about those that Harvey's paper consists of? If RREC is true, then there can be no philosophical discourse at all, and no philosophical thesis, be it RREC or its negation, can be meaningfully articulated. Harvey, however, is not *that* radical; he has quite a viable idea as to how philosophical discourse is possible, and claims that scientific papers are not meaningless after all.

What the distributed view opposes is the code view of language, i.e., the view that there is a well-defined and context-independent mapping from linguistic symbols to their meanings and that symbols can be treated as "abstract public vehicles" (Harvey, 2015, p. 119). The former poses a problem similar to the HPC: the sameness of a symbol is not an objective property of the physical world, but rests on a meaning-laden judgment and on how language users interact with symbols. Wordings, however, exhibit meaning potentials, that is, "the effect that a wording has on the lived experience of someone who perceives it" (p. 123), and meaning potentials "arise from the application of norms to new domains of sensorimotor contingencies" (*ibidem*). They are amenable to complex social coordination and thus could give rise to elaborate systems of communication, such as a philosophical discourse.

It is no surprise that REC could benefit from adopting the distributed view of language and turning into RREC: it simplifies the thesis—content

is simply impossible in any case—and allows one to drop its problematic disclaimer about linguistic content. RREC seems also safe from an adaptation of the scope argument expressed in section 2: one could argue that even if a bacterium could perceive meaning potentials in the world just as we do,[1] these meaning potentials would still be contentless. One can still doubt, however, whether meaning potentials are really distinct from what it takes to be contentful. Note that H&M criticize less radical enactivisms as well: sensorimotor enactivism (O'Regan & Noë, 2001) is argued to rely on the notion of contentful sensorimotor knowledge, and autopoietic enactivism (Thompson, 2007) to be committed to a problematic concept of the sense-making activity of simple cells. Both these views require, according to H&M, positing some sort of content, which, in the light of HPC, is unacceptable. But the distributed view of language shows some remarkable similarities to the autopoietic enactivists' idea of sense-making (Thompson & Stapleton, 2009) as the concept of languaging itself dates back to Maturana (1978), who sought for meaning in the agent–environment couplings and the norms an agent establishes—and it is not entirely clear why it should be content-free. According to H&M themselves, it is not. So maybe Harvey's RREC is more *conservative* than H&M's REC after all? My argument against Harvey's maneuver will be two-fold: first, I will show that the distributed view of language is not entirely content-free and, then, that it scales down to simple signaling systems even more than H&M's sketchy concept of language.

There are at least four reasons why meaning potentials can be seen as distinct from content: (i) they are not arbitrary as public language vehicles are; (ii) they do not presuppose the code view of language; (iii) they are action-oriented and strongly rely on receiver interaction history, and (iv) natural meaning seems observer-relative or at least conventional. Harvey argues (p. 124) that meaning potentials are not arbitrary in the traditional structuralist sense that dates back to de Saussure (see also Hockett, 1960). He provides little explanation, however, why it precludes meanings; it seems one can consistently reject the arbitrariness of language expressions and see them as perfectly contentful at the same time; after all, lexical semantics is thriving in embodied cognitive linguistics research (Lakoff & Johnson, 1980).

Later Harvey claims that "«table» 'refers' to tables because we have all learned to direct our attention towards tables when we hear a sound that we treat as an instance of that word. This means that 'reference' cannot be ascribed to the word itself" (Harvey, 2015, p. 124). There is no reason, however, why one should identify content with a mapping from symbols onto their meanings. As H&M agree, what it takes to determine

content is to determine some satisfaction conditions, which could easily be thought as context- and receiver-dependent tokens. Distributed language theorists themselves sometimes argue that the symbolic mode of description is complementary to the dynamical one and necessary to account for the constraints on the long-scale dynamics of linguistic practices (Rączaszek-Leonardi, 2012).

A more interesting claim is that meaning potentialities stem directly from the collections of norms (established by the agent itself or other agents) that an agent follows (Harvey, 2015, p. 123). Note that in the first case, autonomous norms here are conceived as organism-specific and causally potent—it is the enactivist notion of intrinsic normativity (Thompson, 2007; Weber & Varela, 2002) rather than an etiological account of proper function (Millikan, 1989). Enactivists build their concept of normativity on the biological autonomy of an organism: it is an organism's precariousness and constant need for self-maintenance that renders things in its environment good or bad. It is not clear, however, why, unlike the etiological concept of proper function, intrinsic normativity could not give rise to some satisfaction conditions. Recent advances in artificial life research show that it is a robust notion that could be explicated in terms of qualitative analysis in dynamical systems theory. Barandiaran and Egbert (2013) introduce the concept of a viability space—a region in the system's phase space at which the system remains alive unless conditions change. It is determined by a system's dynamics in relation to the environment: for instance temperature or the presence of food. Viability space in turn enables to define a normative field—a vector describing for each state the minimal alteration of essential variables needed to move the system into a viable space or leave therein. A normative field thus determines what, given any state, an organism should do to continue to exist and can be seen as a way of quantifying autonomous norms in a graded manner (*ibidem*, pp. 15–18). It seems pretty straightforward to use a system's normative field in evaluating signals in its environment and learning proper (that is, adaptive) responses. Note also that it was Bickhard's (2009) idea that autonomy-based norms enable error-detecting capacities, which are crucial in the emergence of genuine (that is, anticipatory) representations.

Action-orientation and receiver-specificity also seem hardly problematic for most naturalist theories of content. Both Millikan (1989) and Bickhard (2009) emphasize, respectively, the role of a consumer in representational systems and the anticipatory character of representations. Yet my argument does not require defending a specific representational role of a content-bearer, which is why it suffices to turn to a simpler and more

elegant evolutionary game-theoretic model of the emergence of signaling networks developed by Skyrms (2010). On Skyrms' account, "[t]he informational content of a signal consists in how the signal affects probabilities" of the future states of the receiver (p. 31). This could be captured more precisely in the framework of a sender–receiver signaling game with evolving strategies: the sender and the receiver choose which signal is to be sent and how to react to it, respectively, according to some strategy. Strategies are subject to evolution through natural selection or reinforcement learning and their probabilities change over time. This is why "[i]nformational content evolves as strategies evolve" (p. 35). A few things should be noted here: Skyrms' notion of informational content is independent of how we measure information (however, in a sender–receiver game the quantity of information is well-defined at any given time) and it does not conflate content with the quantity of information (as *how* the probabilities are changed is something more than *how much* they do). Informational content is a vector quantity covering the entire phase space of a given system (or all the strategies in a given game). It is thus easy to determine satisfaction conditions of a signal as they reduce to set membership: "[a] proposition [expressed as a set of states] can just as well be specified by giving the set of states that the true state is not in" (p. 42). Note that this echoes the primary feature of meaning potentials, i.e. what they are is how they affect the receiver.

It seems that the core of both H&M and Harvey's arguments is that they reject the traditional idea of natural meaning (Grice, 1957). For instance, Harvey (2015) asserts that "speech, writing, maps, plans, models, codes, and all sorts of other phenomena are representations in the sense of having observed representational functions" (p. 124), which presumably means they are conventional or observer-dependent. But on Skyrms' account, conventionality does not imply the existence of a contentful observer and thus no regress takes place. "Conventionality enters when there is enough plasticity in the signaling interactions to allow alternative signaling systems" (Skyrms, 2011, p. 31). *Plasticity* here means that there are some degrees of freedom which are subject to constraining in the course of evolution or learning and manifest a selected pattern; it does not presuppose a mindful observer. Although Skyrms defends the view that all meaning is natural meaning, he sees the evolved conventionality as what leads to a signaling system producing informational content. Informational content is thus evolving due to the constraints of its niche.

At its core, this idea is similar to what H&M call The Strengthened Millikan Maneuver, a view that content is entirely determined by the system that uses (consumes) it. It may be argued that it is an account of content-

creating rather that content-consuming, which renders it harmless to REC (Hutto & Myin, 2013, p. 76). It is, however, the sender–receiver system that gives rise to content and there is only a degree of conventionality in their strategies, as they are constrained by the ecological niche they operate in. This should pose no problem for H&M, for they regard basic minds as essentially extensive (Hutto & Myin, 2013, Chapter 7), but note that the sender–receiver system need not be mindful or contentful in the first place; thus, evolved informational content is perfectly objective and may be subject to subsequent consumption. An evolving sender–receiver system is thus both content-creating and content-consuming.

A similar objection can be found in Harvey (2015) as he remarks that The Strengthened Millikan Maneuver and Bickhard (2009) do provide a credible naturalist account of content, but renders the use of the notion of representation purely rhetorical. This seems hardly to be the case, because Skyrms' signaling networks can be identified in a body of research in animal communication, evolutionary signaling theory, and cell signaling. It is risky at best to call this use "purely rhetorical". (For an extended argument that a similar minimal concept of anticipatory representational mechanism makes a robust notion, see the story of cognitive maps in rats and the role they play in cognitive neuroscience in Miłkowski, 2015.) Surely, one can still argue that all these can be explained in a dynamical fashion, but the issue of the explanatory and, more importantly, heuristic value of representations remains an open empirical question and will be addressed by scientists rather than philosophers. As for now, action-oriented content is still a widely used explanatory and heuristic notion, and calling its use purely rhetorical cries out for an explanation which Harvey does not provide.

Surely, being contentful is not enough to give rise to representation. Thus, Skyrms' model alone is not sufficient for a theory of representational mechanisms. Nevertheless, my argument does not require a claim that something is representational. I have attempted to show that meaning potentials possess informational content in Skyrms' sense and they can be found as early in phylogeny as in cell signaling.

3. Conclusion

The flow of information is traditionally considered one of the key features of life (Solomon, Martin, Martin, & Berg, 2014). All living cells maintain their biological autonomy and respond to the environment through a complex system of regulatory mechanisms called signaling pathways. This mode of

explanation in the life sciences seems different from accounts of the flow of matter or energy as some informational content is posited. Content evolves like any other biological trait and it is responsible for coordinating the functioning of complex biological mechanisms. The case of error in cellular information processing accounts for a number of dysfunctional states, such as cancer, autoimmunity, or diabetes. If there is one thing that complex systems science teaches us, it is that complex adaptive systems are to be explained on multiple levels. It cries out for pluralism rather than eliminativism. It is worthwhile to keep this perspective in mind in a debate over representations in the philosophy of cognitive science. One thing's for sure, being contentful is not sufficient for playing a representational role in a cognitive system; i.e., one can be antirepresentationalist while recognizing the informational role of signaling pathways in living cells.

All things considered, the HPC argument seems quite similar to what Chemero calls a Hegelian argument—an argument "based on little or no empirical evidence to the conclusion that some scientific approach . . . will fail" (Chemero, 2009, p. 7). Yet armchair metaphysical debates seem unpersuasive for a working scientist and REC will receive attention in mainstream cognitive science only as far as it will be developed as a positive research program. It is positing representations that usually lead to novel discoveries in cognitive neuroscience, and there are a number of cognitive phenomena that do not have a credible nonrepresentational explanation even in a sketchy form. Rejecting representations *for metaphysical reasons* and leaving these phenomena unexplained does not look like a promising starting point. This is why Chemero's antirepresentationalism focuses on developing viable nonrepresentational explanations rather than rejecting representational ones. After all, ontological antirepresentationalism is probably false, because almost any complex control system is representational in Millikan's sense (Chemero, 2000). This does not mean, however, that antirepresentationalism could not be successfully defended on epistemological grounds. A different kind of defense has to be carried through, though; genuine antirepresentationalism should be built on case studies of successful dynamical explanations in cognitive science. This may include the famous Thelen et al.'s (2002) work on how the development of object permanence is grounded in the infant's motor development, O'Regan and Noë's (2001) account of visual experience in terms of sensorimotor contingencies, or Brooks's (1991) seminal work in behavioral robotics, but there is still much to be done—especially solving so-called representation-hungry problems (Clark & Toribio, 1994)—before one can claim that representationalism is over.

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NOTE

[1] Most distributed language theorists would consider sense-making necessary though not sufficient for perceiving meaning potentials and languaging. There are, however, accounts of how participatory sense-making, as it is affected by coordination dynamics, can give rise to social cognition (De Jaegher & Di Paolo, 2007), and, subsequently, languaging (Cuffari, Di Paolo, & De Jaegher, 2014). "Through coordinated and exploratory navigations between individual and interactive sense-makings, social creatures generate recursive and replicable behavioral-organizational conventions. This dialectical unpacking guides us to a specific determination of what makes certain forms of sense-making count as languaging" (*ibidem*, p. 4). Whether meaning potentials can be understood in terms of sense-making and scale down to simple autonomous systems is irrelevant to the conclusion of this paper as it suffices to show that biological signaling pathways produce and consume content. It remains an open question whether signaling pathways are autonomous and support sense-making and/or languaging.

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