ontological commitments, framing, and methodologies might be useful for providing different perspectives and measures for other phenomena. If the choice is between explanatory breadth and philosophical consistency, the target article equally makes a case for the former.

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Authors' Response
The Sympoietic Roots of Adaptivity

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> Abstract • We delineate the distinctness of sympoiesis from adaptive notions of autopoiesis and explain why we see it as helpful to the exploration and explanation of agentive and adaptive cognitive systems.

Handling Editor • Alexander Riegler

« 1 » We wish to express our gratitude to all commentators for their insightful comments and constructive criticisms. A central topic in many commentaries was the notion of sympoietic organization, its difference from enactive approaches and possible overlap with adaptive formulations of autopoiesis, and the degree to which its rejection of individualism is reconcilable with agency. In this response, we have sought, to the best of our ability, to delineate the distinctness of sympoiesis from adaptive notions of autopoiesis and explain why we see it as helpful to the exploration and explanation of agentive and adaptive cognitive systems.

« 2 » We have divided the commentaries into two groups, on the basis of a general overlap of topics in the first group. The first group, focusing on enactivism and adaptive autopoiesis, will be discussed in §§3–7. The second group of commentaries will be addressed in §§8–12. Although there is some overlap with the first, these commentaries are primarily concerned with raising various other interesting observations and potential issues.

Autopoiesis, adaptivity, and sympoiesis

« 3 » Several commentaries and questions raised by Tim Elmo Feiten, Tomotej Prosen, Amanda Corris, and Jorge Soto-Andrade converge in their concern with the relationship between sympoietic organization, enactivism, and adaptive autopoiesis. In particular, these authors raise two substantial issues. The first issue is whether the account of *adaptive autopoiesis*, championed by Ezequiel Di Paolo and others, does not encompass many (if not indeed all) of the points of our proposal of sympoietic organization of cognitive systems. The second issue is, insofar as differences between adaptive autopoietic organization and sympoietic organization can be found, what does cognitive science gain from adopting a sympoietic view of cognitive systems, rather than an autopoietic one? To our minds, one of the most important aspects of sympoiesis is precisely its role in explaining the manifestation of systemic adaptivity necessary for cognitive agency. We are indebted to commentators for providing us with the opportunity to expound upon this relationship.

« 4 » Feiten (§11) argues that the enactive view, especially as put forward by Di Paolo already covers the relational composition of living systems, and that, as such, there is no incompatibility between the two accounts. In his Q1, Feiten wonders what is a good example of a relational system with

multiple organism–environment boundaries that we can understand through sympoiesis but not through adaptive autopoiesis. In short, our reply, as argued in the target article and in this section, is *any cognitive (qua adaptive) living system*. The key difference between autopoiesis and sympoiesis as means of conceptualizing the organization of living systems lies in the attribution of causal and temporal primacy to individuality or to relationality. As outlined in the target article, autopoiesis and adaptive autopoiesis explain cognitive systems in terms of the relationally mediated perpetuation of the singular organism: systemic relationality, is in this sense, a property that the system has in service of self-production. However, as we will argue later in this response (especially when discussing Prosen, Corris, and John Sutton), the notion of self-production in living systems should be taken with a grain of salt. In short, we take the literature to be indicating a reversal of autopoiesis, whereby the individual is simply a means for a relational and transformative system. This does not necessarily mean that autopoiesis does not occur but rather that it describes a localized region within the relational system – one whose peculiarly immediate and conservative operation may not apply as a description of the overall organization of cognitive agents.

« 5 » So, does this mean that cognitive agency should be understood as both auto- and sympoietic? To explain why we do not think so, we turn to Feiten's Q2 concerning (a) what replaces these individual-centred accounts and (b) the use of thermodynamic entropy in explaining goal-directed behaviour. The point about what replaces the individual account is unpacked below (see responses to Prosen, Corris, and Sutton), and we wish here to remark upon the relation between entropy-increase and goal-directed behaviour. Feiten delivers his point vividly by comparing an open thermodynamic system to the flushing of a toilet. We take Feiten's meaning to be that distinguishing between cognitive systems and any transient thermodynamic hodgepodge needs something of self-production akin to autopoiesis. And indeed, there is something missing from this scene, but not, we claim, the identification of the system with operational self-production. Just as thermodynamic stability fails to distinguish agentive and non-agentive systems, so does the notion of self-production. We need systemic adaptivity. However, the question remains whether systemic adaptivity needed for cognitive agency may be (a) simply added to autopoiesis like salt to a dish, and (b) added as a property of a single organism. We will unpack why we should reject both assertions in detail by considering Prosen's commentary.

« 6 » In our target article we made our case for sympoiesis on the basis that the kinds of living systems most commonly associated with cognition comprise metaorganismic systems (and that these are more accurately portrayed by sympoiesis than autopoiesis). In the following, we will venture a bit further to offer a possible explanation for *why* that is the case. While we should admit that the sympoietic account formulated here is still in its nascent stages, we did not intend any ambiguity in contending that cognition and cognitive agency are a property of *sympoietic* organization and not of autopoietic organization. As far as we can see, it is specifically the entanglement and production of a multi-layered, meta-organismic structure that allows for the adaptivity necessary for cognitive agency.

« 7 » Prosen (§6) considers the relationship between sympoiesis, adaptivity, and cognition, and offers up three distinct options for how we might understand them: (A) sympoiesis is not adaptive; or (B) it is adaptive; or (C) sympoiesis is not itself adaptive but needs to be supplemented by additional properties in order to exhibit adaptivity. Addressing Prosen's Q1, asking which of these options are in line with our approach, we find ourselves mostly inclined towards options B and C: the sympoietic organization of complex living systems is, if not sufficient for cognition, a core foundation for the systemic adaptivity necessary for cognitive agency. So, along with option B, we must take issue with the autopoietic claim that cognition arises as a relation in the service of the singular organism. Instead, we regard the systemic manifestation of an organism in the sense of Prosen's previously proposed *plastic core* (Prosen 2022), as the (contingent) product of a functional individuation in service of the underlying *relational* system. Instead of viewing adaptivity as an add-on to self-production, we may regard the sympoietic entanglement specifically as laying the grounds for systemic adaptivity and, subsequently, cognitive agency.

« 8 » A conducive way of thinking about this is provided in Gilbert Simondon's notion of *syncrystalization* (Simondon 2020: 168f) in describing the most general form of vital organization: whereas a non-adaptive system may be defined by merely recursive forms of self-individuation, adaptivity enters the picture as the result of the entwining of multiple recursively organized structures. Non-recursive and adaptive forms of organization can be explained by metaorganismic entanglement transforming each individual's recursively self-producing structure into a unified (sympoietic) self-transcending form of production. Transduction thus becomes implemented into the operational structure of the living system specifically as a result of metaorganismic sympoiesis, leading to complex and non-repeating *adaptive* patterns of organization. In brief, the bridge between centric self-production and living "ex-centricity," between circular recursivity and the spiralling innovations of adaptive life, lies in the systematic integration of a mutual transformation of recursive operations made possible by entanglement: in a word, *sympoiesis*. In this sense, sympoietic entanglement may be seen as the link (or the split) between autopoietic and adaptive forms of organization.

« 9 » The role of sympoiesis for adaptivity and the irreducibility of collective units for cognitive agency (Simondon 2020: 168, 240, 339) also provides explanatory support for research into the remarkable cognitive capacities of smaller forms of life, such as bacteria (Dupré 2012; Lyon 2015; Lyon 2020) as well as for Lynn Margulis's notion of symbiogenesis, placing sympoietic entanglement as a key driver of evolution (Guerrero, Margulis & Berlanga 2013). In evolution and ontogenesis alike, it is the entangled structure of life that provides the adaptivity and structural complexity necessary for cognitive agency.

« 10 » Yet perhaps there is something rotten in the state of Denmark. Corris (§4) argues that despite its individualistic grounding, the notion of autopoiesis does a lot of "heavy lifting" in the enactive approach. So, in her Q1 she wonders whether sympoiesis can hope to explain the features

hitherto attributed to autopoietic self-production, such as providing (a) a template for understanding metabolic functioning, as well as (b) a means for delineating between organisms and environments. As to the first aspect of this question, process-based biology reverses the explanatory relationship between organismic individuals and metabolism: instead of explaining metabolism by way of individuals, individuals are explained by way of metabolism (Dupré & Nicholson 2018). So why should we prefer one to the other? Do cognitive systems employ dynamics for the sake of an individual or do they employ an individual for the sake of a dynamic? We will return to this question more directly, in our response to Sutton. For now, we would simply refer to the reasons offered above and note the statistical primacy held by relationality over individuality as described by Kate Jeffery, Robert Pollack and Carlo Rovelli (2019). The second aspect of Corris's Q1 regards the role of autopoiesis in explaining the localization of the organism. In one sense, the reversal in causal direction between individuality and relationality replaces the autopoietic template – according to which relations emerge from interactive structural couplings between distinct interactants in a kind of *fusion* (more on this in our response to Soto-Andrade) – by an image more akin to *fission*: both organism and environment are manifested by the differentiation of their role within the relational system. Instead of relations and environment serving the organism as an end, both organism and environment serve as means for a relational system. Accordingly, the localization of the organism is the result of its functional role within the broader system, and not vice versa (Dengsø 2023).[1] Undoubtedly, this complicates the issues of organismic localization compared to a view that simply takes the organism for granted, but not, we claim, in a way that runs counter to the ambitions of enactivism. The organism remains no more or less tractable than is appropriate to its operation (see also Prosen 2022 and Dengsø & Kirchhoff 2022). Corris's Q2 regards how sympoiesis might help identify and guide resolutions for other problems within enactive theory. In this first part of our response, we have sought to unpack how sympoiesis, as one point of guidance, provides a possible explanation for systemic adaptivity (see also our response to Sutton).

« 11 » Soto-Andrade Q1 suggests that the structural coupling already present in autopoietic organization strongly mitigates the privileging of individual organisms in enactive autopoiesis à la Humberto Maturana and Francisco Varela. As already hinted in the previous paragraph, we do not quite regard structural coupling as mitigating the privileging in question. Here is how Maturana and Varela define it: "structural coupling between organism and environment takes place between operationally closed systems" (Maturana & Varela 1987: 102). As such, structural coupling can be seen as a means of explaining the unmitigable relational properties of living systems starting from the presupposition of an individual-based starting point. Another way to illustrate the issue would be to use a non-living example. Take two pendulums, A and B. When A and B are swing-synchronized, they both undergo transformation to remain synchronized. While this is an excellent example of coupled dynamics, it presupposes clear delineation between the systems in question. We therefore cannot quite agree that structural coupling itself undercuts the privileging of individual organisms.

« 12 » In his §7, Soto-Andrade brings up the example of slime moulds as instantiations of unicellular cognition, posing the critical question of how our hypothesis of sympoietic organization might explain such a phenomenon Q2. As far as we can tell, the case of the slime mould is compatible with our view of sympoiesis. First, as argued by Matthew Sims and Julian Kiverstein (2022), slime-mould cognition includes extracellular elements. It is also worth noting that while slime moulds definitely constitute a fascinating grey area in many ways, to our understanding, claims of their cognitive capacities are typically attributed as a property of slime mould *colonies and collectives* (Vallverdú et al. 2018; Reid 2023). If so, cognition in single-celled organisms such as slime moulds would lend further support for the primacy of collective units for cognition unpacked in §§8f of this response. Finally, slime moulds provide an excellent example of the fission-type explanation of organism localization under sympoiesis: cognitive control is not localized in the central body mass, but distributed along the periphery of the slime-mould body where organism and environment are continually differentiated.

« 13 » Finally, Soto-Andrade Q3 raises the potential implications of sympoiesis for the ouroboric circularity of trying to define cognition from the perspective of an observer. In our target article, we briefly touch on some different theories that address the philosophically much more ambitious task implied by Soto-Andrade's question. Like other broader metaphysical questions (see also responses to Nick Brancazio and Carl Sachs), a direct addressal fell outside the narrow focus of our target article, as Soto-Andrade correctly suspects. That being said, this perspective provides a convenient opening to many of the more disparate and far-reaching queries brought up in the second group of commentaries, to which we now turn.

Biology, sociality, and the joints of the sciences

« 14 » Here we address commentaries whose main themes fall outside the focus of the previous section on sympoiesis and adaptive autopoietic enactivism. Commentaries below raise a broad range of intriguing issues related to biological and sociotechnical notions of individuality, as well as metatheoretical and metaphysical considerations of the relationship between 4E cognition and philosophy of science and nature.

« 15 » Sutton brings out a number of interesting points. While we cannot address them all here, we focus on the two main questions Sutton puts forward in his commentary. Sutton's Q1 concerns the role of individuality on our view: if individuals are products of entanglement, are such constructed individuals still distinguishable, engaging in distinctive cognitive processes and actions? Here, we should note that although individuals are products of relational systems, they are no less genuine causal factors in such systems. Indeed, this raises what we see as one of the important ways in which the sympoietic organization of cognitive systems may help to spur 4E cognitive research: namely by recapturing and critically assessing the role that the production

1| Alternatively, one could describe this dynamic reversal in terms of Karen Barad's (2007) notion of diffractive intra-action (see also Haraway 2016: 33f).

of individuals plays within the context of the broader relational system (whether for navigational purposes, or perhaps even as sociotechnical means of division, control, and disciplining of sympoietic relationality). Our general point was that the individuals *qua* spatio-temporally individuated entities are manifested through sympoietic organization. We are as such indeed dedicated to the important and causally efficacious role of individuals precisely as products of relational systems: it is through their service for the relational system that individuals and boundaries merit Sutton's (§8) prior description of them as *achievements*.

« 16 » In §7, Sutton also accurately notes that our target article does not address the socio-cultural forms of distributed (cognitive) organization, which leads to his critical Q2 of why 4E cognition should treat the integration between cognitive science and biology as more primitive or important than that between cognitive science and the social sciences. In brief, in our target article, we opted to focus on the former because many proponents in the 4E literature explicitly aim to connect their theorizing about cognition with work in systems biology. We have tried to show that despite this ambition, there remains a tension between the latent individualism of 4E cognition and current work in systems biology. Far from asserting the primitiveness of biology, we have simply sought to show that the same entangled organization of cognitive agents readily recognized in our social lives also applies at the biological level (target article §32). In this sense, the sympoietic organization for living cognitive systems is *scale-free*, precisely because it does not give ontological primacy to any particular scale of analysis: the primacy we argue for is the precedence of relationality over individuality in the domain of cognitive systems. To put it another way, appeals to biology sometimes pose as a refuge from the primacy of relationality that predominates the sociotechnical scale. Contrary to this attempt at constructing a shelter for individualism out of organismic self-production, we do not find that a biologically grounded view of cognition supports either an individualistic reductionism of sociotechnical dynamics or the biological favouritism that Sutton (§7) cautions against (see also our response to Brancazio).

« 17 » Sachs, in some ways, takes the opposite route to Sutton, in offering a possible means of taking the sympoietic view beyond notions of the individual. Sachs (§§6–8) succinctly formulates the potential conflict between the anti-individualism evinced by biological research, on the one hand, and the paramount connection of enactivism with phenomenology, on the other. In §7, he offers an insightful and convincing connection between the phenomenological epoché as a form of bracketing "Cartesian meditation" and the individualism of existentialism (see also our response to Marco Facchin's commentary). In this light, the notion of sympoietic organization with respect to cognitive agency might be seen to be at odds with phenomenological research. While we must concede that the concerns here expressed by Sachs reasonably reflect the broad consensus within phenomenological research and enactive research, we would also like to note the potential compatibility with Maurice Merleau-Ponty's later phenomenology (as well as the philosophy of his student, Simondon), emphasizing notions of "chiasmic" intercorporeality and rejecting the assumption of a "tacit cogito" (see also §40 of target article and §8 of our response).

« 18 » In §10, Sachs offers an appeal to Buddhist strands of thought, opening the possibility of a non-individualist grounding of experiential phenomenology, as potentially creating a space for mutual enlightenment between phenomenology and sympoiesis. Being ourselves no experts of Buddhist philosophies we would foremost express our gratitude for Sachs's insightful and supportive considerations. However, we would also – hoping that our ignorance might excuse our caution – like to be clear about the extent to which the fundamentally relational and entangled view that we see reflected in biology and other avenues of research does not erase the role of individuals as causally efficacious and non-illusory functional operations of relational systems (see also our response to Sutton above in §15). Understanding the contingency of individuals uncovers their function and efficacy within the broader living assemblage. In another sense, what sympoiesis regains through the erosion of pregiven individuality is the crucial adaptive aspect of life as a concretely *generative*, developmental process. This brings us to Facchin's commentary.

« 19 » Whereas Sachs traces the individual centredness of enactive cognition to the inheritance of Western philosophy through phenomenology and existentialism, Facchin (§§6, 8–9) argues that both enactivism and the extended-mind thesis, as well as our own proposal, fail to escape the clutches of Cartesianism, either by way of spatially extended computationalism or by way of ties to intentionality. Facchin (§12) seems to imply that the sympoietic view of cognitive organization is the third-wave view of the extended mind. In our target article, we take some care in distinguishing between the two views, given that the sympoietic proposal presented does not hedge its significant claims. For example, a third-wave view states that the assembly of cognitive systems may sometimes be akin to a sympoietic assembly, but it need not always be so: Kirchhoff & Kiverstein (2019, 2020) thus distinguish between ultimate and proximate causes in explaining phenomena,[2] and consider the phenomenon of culture shock, arguing that in order to explain the experience of culture shock, one needs to include ultimate causes as part of one's proximate explanation. Note, the view is *explanatory*. It is not the metaphysical claim that parts of our distant past are proper parts of a minimally sufficient constitutive base for cognitive processes.

« 20 » That said, Facchin takes the sympoietic view to entail that "at least some cognitive processes take place at *slower* timescales" (§12) than processes unfolding in the here and now, as per other 4E cognitive approaches (§11) – and thus are better left to biologists than to cognitive scientists (§13). While we do not quite recognize this commitment that cognition occurs at *slower* timescales, we do contend that the appeal to adaptivity as a necessary component of cog-

2| Ultimate causes are part of diachronic explanations. For example, why birds migrate concerns various things to do with weather, food resources, and so on, which unfold over diachronic timescales (historical, evolutionary). Proximate causes are part of synchronic explanations. For example, how birds fly will make reference to internal mechanisms of the bird in the here and now.

nition and cognitive systems makes an important difference. Especially, Facchin's contention that cognition happens in the "here and now," if meant to indicate that cognition falls somehow below or outside the scale of living systems' generative development, would seem to undermine the connection of cognition with adaptivity altogether. By contrast, if cognitive systems are adaptive (which, as we have argued in the first part of this response would make cognition intimately related to sympoietic organization), then cognition cannot be isolated from the generativity of such systems at longer scales of temporal development.

« 21 » Thematically related to Facchin's call to separate systems across temporal scales, as well as to Soto-Andrade's broadly philosophical question, Brancazio advocates for the separation of the different profiles of cognitive systems across different fields of enquiry. As laudable as philosophical consistency may be, Brancazio thus advises that we should maintain a pluralistic division between enactivism as a philosophy of nature and (systems) biology. Although we appreciate this meta-theoretical point, it is not entirely clear to us whether questions regarding the organization of cognitive agents necessitate an accompanying philosophy of nature. Indeed, as outlined in §40 of our target article, such encompassing discussions are quite beyond our scope, and our purpose was simply to focus on the biological basis of cognitive agency. As such we did not intend to make any claim as to whether enactivism should seek to offer a philosophy of nature.

« 22 » Brancazio (§12) wisely cautions us against privileging one ontological level or framing over another and forcing enactivism to conform to the work of dynamical systems theory, given their different focus. For example, Brancazio (§3) brings up the point that developmental systems theory often has been more directly concerned with the genetic makeup of biological systems. Indeed, as noted in §§27, 30, 31 of our target article, genetics is one important manifestation of multiorganismic structure as regarded in the biological literature. In our article, we have, on the one hand, sought to suggest how these and similar aspects of multiorganismic organization might be accounted for by cognitive science, and, on the other hand, sought to sketch out a possible appropriate framework. However, as noted in the first part and in our response to Sutton, the sympoietic privileging of relationality over individuality pertains specifically to cognitive agency, but not to any scale or framing.

« 23 » While we do not object to the general sentiment that there is always more than one perspective one can have on a system, we also think that an interdisciplinary appeal to the biogenic aspects of cognitive adaptivity and agency could be informative for frameworks within cognitive science dedicated to a biologically grounded understanding of cognition. And it seems to us no infringement upon the status of cognitive science to consider how cognitive agency precisely emerges; conversely, it is not clear what a biologically grounded cognitive science would gain from maintaining an individual-focused view if cognitive agency happens to be a property of meta-organismic systems. After all, as Brancazio points out in §8, 4E cognition is no stranger to challenging received wisdom about the scope and scale of cognitive processes and systems on the basis of an appreciation for the continuity of life and mind.

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