



Life–mind continuity: untangling categorical, extensional, and systematic aspects

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Abstract

In this paper, I argue that current attempts at classifying life–mind continuity (LMC) feature several important ambiguities. We can resolve these ambiguities by distinguishing between the extensional, categorical, and systematic relationships that LMC might encompass. In Sect. 1, I begin by introducing the notion of LMC and the theory behind it. In Sect. 2, I show how different ideas of mind shape different approaches to continuity and how to achieve its aim. In Sect. 3, I canvas various canonical formulations and classifications of LMC; I then demonstrate that they retain important ambiguities. Section 4 builds on this by arguing that we must conceive of the extensional and categorical aspects of continuity independently. In Sect. 5, I show further that current literature has underexplored multiple systematic aspects of continuity. I then take a constructive approach in Sect. 6 by providing a classification model for LMC based on extensional and categorical commitments. Here, I comment on aspects of the thesis omitted from the model but essential for a full classification and thorough comparison between various approaches to LMC. All of these arguments lay the foundation for more exhaustively classifying accounts of LMC.

Keywords Life–mind continuity · Biogenic cognition · Enactivism · Basal cognition · Metaphysics

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1 Introduction

What is life–mind continuity (LMC)? The idea of LMC emerged in various fields owing to a growing appreciation that *complexity* and *self-organization* play crucial roles in both biology (e.g., Kauffman, 1993) and cognitive science (e.g., Stadler & Kruse, 1990). This realization seemed to indicate that life and mind¹ were closely connected and that properly understanding both would require attending to their connection (Stewart, 1992). Pioneering work in this area included the theory of autopoiesis, or AT. AT was an organizational account for demarcating living from non-living systems. According to this theory, life is a self-regenerating system composed of a circular network of processes, and this network maintains itself by environmental interaction. Because interaction with an environment helps to maintain the system’s integrity, that process began to be framed as one of cognition. AT thus offers one of the first articulations of LMC: “*Living systems are cognitive systems, and living as a process is a process of cognition*” (Maturana & Varela, 1991, p. 13, original emphasis).

AT was tremendously influential for researchers in both cognitive science and biology because it underscored the connection between the two disciplines; it also greatly shaped research in embodied cognition. After the advent of research on artificial life, Peter Godfrey-Smith formulated more explicitly the idea of a continuity between life and mind (Godfrey-Smith, 1994, but see also; Stewart, 1992, 1995). From the work of Herbert Spencer and John Dewey, LMC came to be understood as the proposition² that life and mind share fundamental organizational properties, and that those properties are enriched in the case of mind. Later, it was proposed that LMC could help to constitute a novel biological or *biogenic* approach to cognitive science, which would therefore study cognitive processes using biological principles (Lyon, 2006; Wheeler, 1997). LMC would thus guide us in understanding the relationship between life and mind, and the biogenic approach could use that project, alongside other methods and theories on life and mind, in its studies.

Since that time, LMC and biogenic approaches to cognition have gained both influence and support. Most notably, the view of *enactivism*, particularly autopoietic enactivism and radical enactivism, embraces LMC as a central feature of its theories (see e.g., Di Paolo et al., 2018; Froese & Di Paolo, 2009; Hutto & Myin, 2013; Myin & van den Herik, 2021; Thompson, 2007; Villalobos, 2013). Even more recently, the *free energy framework*—one of the most popular current neurocognitive models—has been proposed to support LMC (see e.g., Bruineberg et al., 2018; Kirchhoff, 2018; Sims, 2021b; Wiese & Friston, 2021). Certain versions of *ecological psychology*, such as the skilled intentionality framework, also support LMC (Bruineberg et al., 2019). These proposals are often skeptical about representational accounts of cognition, but LMC is not limited to non-representational accounts (Bickhard, 1998;

¹ Henceforth, I use the terms “life and “mind” frequently. In this context “mind” is ambiguous, as it can refer to either cognition or sentience (see Sect. 2 for discussion). As I use the term, it refers to either the class of biological/cognitive systems or all occurrences of such systems. In general, I prefer the terms “life” and “mind” in contexts regarding the general organizational properties of biological/cognitive systems.

² In most cases, LMC refers to the *proposition* that life and mind are continuous. In some cases, it refers to the *proposal* that life and mind are continuous. Context will differentiate these two uses.

Wheeler, 2011). Furthermore, new findings in many areas of biology have continued to offer greater evidence for cognition among all life-forms, including bacteria (Shapiro, 2021; Westerhoff et al., 2014), fungi (Etchebeste & Espeso, 2016; Money, 2021), plants (Calvo et al., 2019; Gagliano, 2015), and animals (Birch et al., 2021; Vallortigara et al., 2010). In response, a view known as *minimal cognition* studies (Brancazio et al., 2020; Van Duijn et al., 2006), or, more recently, *basal cognition* studies (Lyon et al., 2021), has attempted to synthesize and integrate all of these findings within a unified framework. These approaches proceed with a commitment to a biogenic approach to cognition, and several theoretical proposals in this field appear to support LMC (see e.g., Bechtel & Bich, 2021; Keijzer, 2020; Levin, 2019; Lyon et al., 2021).

In general, there is much overlap between these different approaches (see e.g., Heras-Escribano, 2021), but also questions about their compatibility (for enactivism and inter-activism, see (Bickhard, 2016); for FEP and enactivism see (Di Paolo et al., 2022); see (Heft, 2020) for differences between ecological psychology and enactivism). Thus, LMC is not a singular paradigm or model for cognition and life. Rather, it is a general commitment about how to study and explain their relationship.

With the many connections between so many different views, it is important that we have some general understanding of LMC to clarify what the various commitments amount to. My goal in this paper is thus to contribute to that general understanding. I shall focus in particular on current formulations of LMC, because I believe that they feature several ambiguities that require untangling. I argue that these ambiguities exist because we have failed to distinguish sufficiently between three distinct aspects of LMC. I term these the “extensional,” “categorical,” and “systematic” aspects. By *extensional* aspect, I mean (the set of) all occurrences of life and mind, as well as whether they share members or have the same occurrences. The extensional aspect of LMC concerns whether some instances of living systems are also cognitive systems, or vice versa. By *categorical* aspect, I mean the categories of life and mind, with a specific focus on the properties constituting those categories and the relationships between those properties. The issue concerns claims about how properties of life are taken to be constitutively involved in the category of mind, or vice versa. A source of confusion here is an absence of coordination between the *type* of property taken to characterize the categorical relationship between life and mind. LMC’s categorical claims have been stated in terms of structural, organizational, and functional properties. The term “categorical” serves here as a catch-all referring to all these property types. The type of property involved in categorical LMC claims depends on background assumptions, and, most importantly, on how one defines notions of life and mind. Lastly, by *systematic* aspect, I mean the various system aspects and scales at which continuity can exist. This issue concerns whether continuity applies to internal modes of a system or to the system itself, and at which timescales.

LMC claims often implicate the extensional, categorical, and systematic aspects, but none has been explicated individually. One reason why is the tendency to formulate “stronger” and “weaker” versions of LMC. I shall argue that this tendency obfuscates these distinct aspects and confuses definitions and categorizations for LMC.

My three-fold distinction comes with certain metaphysical presuppositions, of course. Crucially, it relies on the assumption that instances of a category and the cat-

egory itself can be clearly distinguished, either *de re* or *de dicto*.³ Whether this is possible depends on one's preferred ontology. Although I shall not argue for or against the assumption here, I nevertheless maintain the distinction as useful in this context. Its utility manifests in various ways. First, the distinction is often tacitly assumed in current attempts to define and classify LMC. It can thus serve as a helpful heuristic for uncovering commitments hidden in current approaches to LMC. Furthermore, by not assuming any specific ontology, the distinction keeps open the solution-space for LMC, enabling underappreciated approaches.

Finally, LMC does involve more than these three aspects. I discuss other connections in the final section.

2 Theoretical context and the notion of mind

LMC involves three elements: life, mind, and continuity. I do not treat here the first two nor the rich literature surrounding them. It is continuity that grabs my attention and that, despite being the load-bearing concept in LMC, has not been sufficiently explored. The notions of life and mind are of central importance for LMC, however, and essential for any proper evaluation of its truth. I wish to therefore emphasize how the notion of mind can modify LMC's theoretical aims. This emphasis matters for two reasons. First, the notion of mind is used in various ways in discussions on LMC, with mind and cognition often used interchangeably. This shift can drastically affect how we conceive of the extensional and categorical relationships of life and mind, and we ought to remember it when classifying LMC. The purpose of this section, then, is to illustrate some conceptions of mind that can modify a classification for LMC. The second reason this emphasis matters is that these various notions of mind have more systematic implications for how to conceive of the theoretical aim of LMC. I wish to indicate two ways in which LMC can figure in this theoretical discourse.

The first approach to this issue proceeds from the standpoint of conceptual analysis. On that basis, it seeks to understand the categorical relationship between life and mind. In this approach, the metaphysical aspects of LMC are most pertinent. This is best exemplified by Evan Thompson's famous, extensive treatment of LMC. He proposes a "deep continuity of life and mind," claiming that the mind's self-organizing features are an "enriched" version of the self-organizing features of life (Thompson, 2007, p. ix). He adds that "mind is life-like and *life is mind-like*" (Thompson, 2007, p. 128, my emphasis). He posits an enactivist account inspired by autopoietic theory and claims that life and mind are co-extensive, and argues that sense-making is a necessary feature of life. Thompson understands cognition in terms of sense-making, but he insists that a solely cognitive version of LMC is insufficient. Instead, "the continuity includes the subjective and experiential aspects of mental life as well as the cognitive aspects [...] certain basic concepts needed to understand human experience turn out to be applicable to life itself" (Thompson, 2007, p. 129). This is Thompson's "deep" version of LMC, sparked by the phenomenological tradition. He reinterprets

³ I thank an anonymous reviewer for raising this point.

Hans Jonas' phenomenological account of continuity (Jonas, 1996, p. 60), which for Jonas meant that “the great contradictions that man discovers in himself” are already found within the most primitive single-celled organisms. These inner contradictions are three: needful freedom, a meaningful Umwelt, and self-transcendence. Thompson reinterprets them in terms of AT (Thompson, 2007, pp. 149–157). This phenomenological version of LMC has seen much discussion (see De Jesus, 2016; Kee, 2021; Prokop, 2022). In this context, the purpose of LMC is to help understand organic life in intentional terms, while reinterpreting the distinctive aspects of human existence as revealing a certain kinship among all organic life.

Enactivist literature understands the notions of mind and cognition in many ways. For instance, Thompson (2007) and Kirchhoff and Froese (2017) take cognition, understood as sense-making, to provide a minimal notion of mind. They then position sentience and consciousness as later evolutionary developments arising with nervous system function. Froese and Di Paolo (2009, 2011) agree that cognition gives a minimal notion of mind, but they deny that sense-making is sufficient for it; they claim instead that cognition requires nervous system function. Thompson later revised his view on sentience; see Thompson (2022) for a discussion on various approaches to cognition, mind, and sentience.⁴

The second approach contrasts with that of Thompson and the enactivist take on LMC. This one proceeds from empirical investigation, and uses LMC as a preliminary delimiter for a domain of scientific inquiry. Here, LMC's commitments are bracketed by instrumental concerns and are conditional on the findings of open-ended empirical studies. For instance, Keijzer (2020) seeks to dissociate mind and cognition. He criticizes intuition-based ascriptions of cognition and mind by arguing that this practice makes it harder to explicate clearly and stably a target domain for the cognitive sciences. According to Keijzer, the notion of mind links to debates on free will, responsibility, and rationality, none of which belong to the concerns of cognitive science (Keijzer, 2020, p. 146). Here, cognition is reinterpreted and developed as a scientific concept tied to a material domain of research. On Keijzer's approach, then, cognition becomes a revisable theoretical concept that we can and must adapt to findings within this target domain. To establish that domain, he proposes the idea of *cobolism*, which refers to how living systems systematically encompass structures, processes, and external events to maintain their fundamental metabolic processes (Keijzer, 2020, p. 151). Keijzer emphasizes that, while cobolism does relate to the perspectives of AE and AT, these often define cognition and mind so that they bear conceptual connections to life. In contrast, Keijzer's approach should be taken as an empirical posit, whose “aim is not to define or describe cognition but to specify the domain that sets material constraints on cognition,” using a toolkit criteria for cognition (Keijzer, 2020, p. 150). With this proposal, cognition is a revisable concept specified through empirical study, and it forms the basis of what he terms the cognitive life sciences—that is, a biogenic approach to cognition.

Biogenic approaches generally emphasize a biological version of developmental continuity (Lyon, 2006). Recently, Keijzer and coauthors have noted that this con-

⁴ I thank an anonymous reviewer for mentioning this source. Space limitations prevent me from treating it in detail.

tinuity involves recognizing that “the information-processing dynamics of ‘simpler’ forms of life are part of a continuum with human cognition” (Lyon et al., 2021, p. 2). This type of LMC, however, should be understood merely as guiding empirical research.

LMC thus cross-cuts various notions of mind and cognition: both non-representational and representational, and both conceptually determined and empirically open-ended. The goals of these authors vary widely. In light of all these different views, then, we can say that (1) how we ought to specify the relationship between life and mind and (2) how we ought to evaluate LMC in light of these different purposes, both depend on the broader theoretical context surrounding LMC.

3 Untangling epistemological and ontological aspects

There currently exist many formulations for LMC with no consensus definitions, classifications, or comparison methods. In this section and the two following, I argue that current formulations face three major problems. The first, treated in this section, is that epistemological terms tend to appear in ontological formulations of LMC.

In his discussion of Dewey’s and Spencer’s conceptions of life and mind, Godfrey-Smith (1994) gives a canonical formulation of LMC. He distinguishes two types of continuity: methodological and ontological. According to methodological continuity, understanding the mind requires understanding the role it plays within whole living systems (Godfrey-Smith, 1994, p. 320). Most subsequent interest in LMC, however, has focused on ontological formulations of continuity. There, Godfrey-Smith distinguishes between weak and strong versions of LMC:

Weak continuity: Anything that has a mind is alive, although not everything that is alive has a mind. Cognition is an activity of living systems.

Strong continuity: Life and mind have a common abstract pattern or set of organizational properties. The functional properties characteristic of mind are an enriched version of the functional properties that a fundamental to life in general. Mind is literally *life-like*. (Godfrey-Smith, 1994, p. 320, original emphasis)

This formulation of LMC has since become standard, especially with those who place special emphasis on strong versions of continuity (e.g., Froese & Di Paolo, 2009; Kirchhoff, 2018; Prokop, 2022; Stillwaggon, 2005; Thompson, 2007; Villalobos, 2013; Wheeler, 1997; Wiese & Friston, 2021). As Stillwaggon (2005, pp. 48–49) noted almost 20 years ago, the explicit formulation of LMC merely articulates a widespread underlying sentiment that is not always formulated in terms of LMC. Since Stillwaggon’s comment, this sentiment does not seem to have changed. In fact, new advances in the life sciences have suggested that cognitive behavior exists in most living systems, thereby reinforcing the idea that life and mind are connected (e.g., Baluška & Levin, 2016).

We can now consider the first major problem faced by current formulations of LMC. This problem is that the formulations do not clearly distinguish the episte-

mological and ontological aspects of the thesis. Godfrey-Smith's formulation, for example, is typically paired with the following one from Andy Clark:

The thesis of strong continuity would be true if, for example, the basic concepts needed to understand the organization of life turned out to be self-organization, collective dynamics, circular processes, autopoiesis, etc., and if those very same concepts and constructs turned out to be central to a proper scientific understanding of the mind. (Clark, 2001, p. 118)

Clark's formulation is intended to state the strong continuity thesis more concretely than Godfrey-Smith's—but, in fact, the two formulations are distinct and could entail distinct commitments. First, Clark states the thesis in terms of truth-conditions for strong continuity, but then specifies those conditions by means of “concepts” and “understanding.” This specification undermines the ontological import of strong continuity and gives it an epistemological spin. Second, and more importantly, Godfrey-Smith's formulation involves two components: (a) a commonality of organizational/functional properties, and (b) the enrichment of those properties. Clark's formulation need not imply either component. For example, it is possible that one and the same concepts are central to our understanding of life and mind, without their centrality implying that the properties life and mind share are enriched in the relevant sense.⁵ Furthermore, Godfrey-Smith's conditions may be fulfilled without entailing that the same concepts are central to both life and mind. If the enrichment of shared properties is sufficiently strong, the properties might differ so much that using the same concepts would no longer be appropriate, or that they would no longer be central to any *understanding* of mind.

Nevertheless, while Clark's and Godfrey-Smith's formulations may not be equivalent, many still take Clark's to capture important aspects of strong continuity (e.g., Kirchhoff, 2018; Prokop, 2022; Thompson, 2007; Wiese & Friston, 2021). And, on this basis, some have conflated the epistemological and ontological aspects of LMC.

Wiese and Friston (2021, p. 2), for instance, lean into Clark's formulation by claiming that strong continuity involves an explanatory and a conceptual component. *Explanatory continuity* means that the principles and concepts that account for basic forms of intentionality scale up to more advanced instances of cognition. *Conceptual continuity* means that basic forms of intentionality can be understood as aspects of aboutness. These two components are both given in terms of explanation, concepts, and understanding, and thus depart from the original ontological formulation.

This departure is a problem for two reasons. First, in emphasizing the epistemological and methodological components so heavily, it is no longer clear whether the stated conception is still actually a version of strong continuity. For these authors, strong continuity *entails* that “the very concepts that account for basic minds [...] are also central to understanding higher minds” (Wiese & Friston, 2021, p. 8/13),

⁵ Note that this point would also imply a specific theory of concepts, whereby the same concept, such as “self-organization,” would (ontologically) imply that different entities would possess the same property of self-organization. Although this implication fits within a mainstream doctrine of concepts, certain other views, such as non-atomic pluralism, could resist such an implication.

and so it seems as if they are discussing the *implications* of strong continuity, rather than the thesis itself. That is not necessarily the case, however, because as we have seen, Clark's formulation does not entail Godfrey-Smith's, nor vice versa. Second, in invoking notions of aboutness, Wiese and Friston by fiat exclude some non-representational accounts of LMC (e.g., Di Paolo et al., 2018). Hence, conceptual continuity, as they construe it, cannot be a necessary feature of strong continuity—several authors reject “aboutness” while holding strong continuity.

In conclusion, we should not take conceptual continuity, in either Wiese and Friston's sense or in that of Clark, as necessary for strong continuity. We should discard formulations of LMC given in these terms. As shown previously, both mind and life are important to formulate a theory adhering to LMC, but using such specific notions makes cross-theoretical comparison and fertilization difficult.

4 Untangling categorical and extensional aspects

The second major problem with current formulations is that they do not sufficiently distinguish between extensional and categorical commitments. Two ideas connect to this problem: first, that cognition depends on a biological system; and second, that life and mind co-emerge (Kirchhoff & Froese, 2017, pp. 15–16). The first originates with Godfrey-Smith (Godfrey-Smith, 1994), while the second comes from autopoietic theories more broadly. Particularly influential here has been work by Stewart (1992, 1995), Michel Bitbol and Pier Luigi Luisi (2004), and Thompson (2007). Wiese and Friston (2021) do not share the first idea, because they claim that strong continuity does not entail the necessity of life for mind. Froese and Di Paolo (2009, 2011) do not share the second idea. Thus, we see divergence regarding core commitments.

This second major problem stems from ambiguities left open by Godfrey-Smith. We see them in his remark on cognition's dependence on biological systems:

If the pattern of organization characteristic of mind includes the pattern characteristic of life, then anything which thinks must have a lot of what it takes to be alive. (Godfrey-Smith, 1994, p. 320)

Understood from the perspective of strong continuity, this reasoning is erroneous. One of two things is true: either the shared pattern is sufficient to characterize life, and thus a cognitive system *is* a living system; or the shared characteristics are merely necessary for something to be alive, and thus a cognitive system is *not* a living system, and is just *like* such a system. If strong continuity implies weak continuity, then all cognitive systems must be living systems, but this implication does not hold if they share only common characteristics necessary for life. Having a lot of what it takes to be alive and having what it takes to be alive are not the same things. Weak continuity requires the latter. Godfrey-Smith later realized this ambiguity, but clarified that he had in mind a version of strong continuity, which implies weak continuity (Godfrey-Smith, 1998, p. 76).

We should therefore distinguish two versions of strong continuity: one entailing that cognition is restricted to biological systems, and one without that entailment.

Failure to make this distinction gives rise to the disagreement mentioned in Froese and Di Paolo (2009, 2011), who are thinking of the first version, while Wiese and Friston (2021) are thinking of the second.

What is the source of this confusion? To answer this, we must also consider the second idea mentioned above, namely that life and mind co-emerge. This idea originates with AT and appears in several places (e.g., Bedau, 1998, p. 137), but it does not follow from Godfrey-Smith's formulation of LMC. Michael Wheeler was the first author to notice this point, claiming that "it does not follow from strong continuity that life and cognition are *the same* (in the sense of 'same' articulated by Varela and Stewart)" (Wheeler, 1997, p. 11, original emphasis). The idea of co-emergence, then, is in a certain sense even stronger than that of strong continuity, despite co-emergence sometimes passing under the label of strong continuity. To resolve the issue, Matthew Sims defines "the entailment thesis" (Sims, 2021b, p. xiv), which he describes as "where there is life there is mind." For Sims, the entailment thesis is a determinate of "strong continuity," which in turn is a determinate of "weak continuity."

This distinction between strong continuity and entailment continuity is commendable, but the explanation falters. If strong continuity helps to determine the determinable weak continuity, then strong continuity would imply weak continuity. Because some versions of strong continuity do not imply that mind is necessarily an activity of life, then weak continuity cannot be a determinate of strong continuity. Do entailment and strong continuity, then, stand in a determinate–determinable relation? One argument suggesting that they do is that the extensional relationship between life and mind could hinge on the strength we assign to the common categorical principles shared by both phenomena. For instance, if those principles are merely necessary for life, then nothing is implied regarding extension; if they are sufficient for life, then there must be some shared extension.

We could then turn this reasoning around and ask whether these common principles are necessary or sufficient for mind. For instance, if they are necessary for mind and sufficient for life, then there will be shared extension, and so strong continuity will imply weak continuity. If the common properties are necessary and sufficient for both life and mind, on the other hand, then we should expect co-extension for life and mind such that there can exist no living systems that are not also cognitive systems, and vice versa. As a result, it would be true that wherever there is mind there is life, and wherever there is life there is mind.

In my view, however, reasoning about the categorical properties and extension of life and mind in terms of conditions for necessity and sufficiency is misguided. First, the fact that life and mind share categorical properties does not by itself imply anything about whether those properties have a modal status as necessity and sufficiency conditions. Because biological systems are historically contingent, logical dependence relations may not be suitable for reasoning about their categorical dependencies. Second, and most crucially, extension and categorical similarity can obtain independently. It is entirely possible that life and mind can be co-extensive for reasons other than shared categorical properties—for example, co-extension can obtain for non-categorical reasons, like contingent environmental conditions. Hence, we must distinguish the conditions of categorical entailment from those of co-extension, since they all rely on different considerations. The conditions of categorical entail-

ment consider metaphysical category relations, while those of co-extension involve whether (some of) the members of each category are the same under some domain. Thus, the “where there is life there is mind” formulation of entailment allows for different interpretations, and these cannot be described by the determinate-determinable relation. Life and mind may be co-extensive but for non-categorical reasons, or the extension of life may be a proper part of the extension of mind.

The central cause of this problem, then, is the following: entailment continuity, strong continuity, and weak continuity are not just stronger or weaker versions of the same thesis. To take them as such—as in terms of a determinate–determinable relation—assumes that categorical and extensional aspects may be directly translated into each other. However, that assumption ignores the many complications in the relationship between categories and their extension. I suggest instead that we should consider the categorical relationship and the extensional relationship independently of each other, on their own terms, before we examine how they may combine.

My view helps to show that most formulations of LMC assume a metaphysical asymmetry between life and mind. Life is generally presupposed to be the more fundamental phenomena, or that life and mind at most co-emerge as reciprocal and constitutive aspects of organic systems. This asymmetry has been termed “the subset view” (McGivern, 2020), and certain accounts invert this order by taking cognition as the more basic phenomena (see Kawade, 2013). The basic idea is that life instantiates a more particular version of the dynamics sufficient for cognition. So, although it is true that “where there is life there is mind,” it is not true that where there is mind there is life. I note this possibility because, while it does diverge from typical subset-assuming LMC accounts, it might sit better with certain contemporary metaphysical views on mind, such as panpsychism, idealism, and cosmopsychism (Goff, 2019; Shani, 2022).

5 Untangling systematic aspects

The third major problem for current formulations of LMC is ignorance toward significant differences in LMC’s more systematic aspects. This problem worsens when authors do not state what LMC entails for continuity between biological systems or between cognitive systems. Accordingly, this section presents four systematic aspects of LMC that have yet to be fully articulated.

The first systematic aspect of continuity is one given in terms of bio-cognitive continuity internal to system functioning.⁶ Consider Andy Clark’s discussion in his book *Mindware* (Clark, 2001). Clark discusses LMC in the context of radical embodied cognition, which states that we should understand cognition in the non-representational terms studied by, for instance, dynamical systems theory. The fact that most non-representational descriptions of cognitive processes are applied only to

⁶ I bracket considerations on how to define “function.” The functional properties *could* be taken as constitutive of the categories of life/mind, in which case they would also tie into considerations on categorical continuity. But this need not be the case. Either way, systematic aspects of continuity would have to be considered independently. In this section, similar considerations hold for talk about “structural” and “organizational” properties.

“low-level sensorimotor engagements” raises the issue, Clark argues, of how exactly the descriptions could support such a general thesis about cognition. As Clark puts it, the question raised is “What, in general, is the relation between the strategies used to solve basic problems of perception and action and those used to solve more abstract or higher level problems?” (Clark, 2001, p. 135). That is, if low-level sensorimotor engagements can be explained in non-representational terms, can higher-level cognitive processes be so explained as well? If radical embodied cognition is true, then the answer must be yes. Here, LMC becomes important, because it can underpin the transition from lower to higher levels by claiming that lower-level cognition is continuous with higher-level cognition. Clark calls this “cognitive incrementalism”: getting to higher-level off-line cognition by iterating on on-line cognition. In a previous section, he explains the observation behind the idea:

The shape and operation of higher level cognitive processes have probably been built, in some highly path-dependent fashion, on a more evolutionary basic substrate of perception and sensorimotor control. (Clark, 2001, p. 130)

LMC underpins a continuity from low- to high-level cognition within an organism, which can therefore explain cognitive *functioning* in similarly non-representational terms. Di Paolo et al. (2017, 2018) offer a related conception of LMC, as they understand the view to encompass the constitutive interpenetration and relative autonomy of the organic, sensory-motoric, and social aspects of a human body’s cognitive functioning.

This would be a continuity conception of the internal cognitive function of psychological and organic aspects for a given system. We must therefore distinguish it from a second and third systematic aspect of LMC, ones applied to bio-cognitive development. For example, Froese and Di Paolo (2011, p. 15) have emphasized that LMC should be conceived in ontogenetic terms, on which we view continuity as a developmental trajectory from single-celled organisms to multi-cellular cognitive agents. Ontogenetic views are not the only possible approaches to developmental continuity. Hutto and Myin (2017, pp. 121–146) emphasize evolutionary continuity at phylogenetic scales, thereby taking an intersystematic approach to bio-cognitive continuity.

We see the fourth systematic aspect by attending to basal cognition research, and it takes a comparative approach to continuity. Here, we draw on a distinction made by Bar-On (2013, 2018). She discusses “continuity skepticism,” which claims that it is impossible to provide a continuous explanation of how human cognition and mentality emerge from non-humans. In this context, she identifies two types of (dis)continuity. *Synchronic continuity* concerns whether there is continuity among the cognitive and mental capacities of humans and non-humans as they currently exist. *Diachronic continuity*, on the other hand, concerns whether there is continuity in the natural history of the human mind’s development. Synchronic continuity is importantly different from the functional continuity discussed earlier. The synchronic account often appears in a comparative sense relating currently existing species across an ordered spectrum (cf. Lyon et al., 2021; Sims, 2021a). It thus cross-cuts phylogenetic differences while abstracting from developmental processes. On the other hand, functional

continuity restricts its focus to a single (type of) organism system and considers the relationship between different types of organic and cognitive functioning internal to that system (cf. Di Paolo et al., 2018; Spivey, 2008). Synchronic continuity and functional continuity therefore differ while both abstract away from developmental aspects at ontogenetic and phylogenetic scales.

In light of this discussion, we can distinguish four systematic aspects of LMC:

1. **Functional continuity:** the internal bio-cognitive functioning of a system at some given (e.g., mature) developmental phase is continuous.
2. **Comparative continuity:** the bio-cognitive properties between present systems are continuous.
3. **Ontogenetic continuity:** the bio-cognitive development of a system at ontogenetic scales is continuous.
4. **Phylogenetic continuity:** the bio-cognitive development of phyla at evolutionary scales is continuous.

Functional and comparative continuity are both synchronic, while ontogenetic and phylogenetic continuity are diachronic. Comparative and phylogenetic continuity take an inter-systematic approach, while ontogenetic and functional continuity are intra-systematic. These distinctions are neither exhaustive nor exclusive, but we must recognize that each systematic aspect entails distinct commitments.

Several things complicate that recognition. First, there may be a continuous development, either ontogenetically or phylogenetically, of an organization of life that yields a cognitive system, while there are at the same time discontinuities in the functional organization internal to that system. Likewise, there may be continuity in the functional organization of cognition and life internal to the system, even though the organism arises through some discontinuous development. A second complication is that internal bio-cognitive functioning need not be conceived in functional terms. For instance, authors sometimes present continuity in structural or organizational terms. There may thus be a continuity of organizational or structural properties between such systems, while at the same time there exist drastic functional discontinuities. As Clark also notes, “[m]uch depends, of course, on what we are here to understand by the phrase ‘no difference between.’ For in many interesting instances [...] we can discern both a kind of (often structural) continuity alongside some quite radical functional discontinuity” (Clark, 2001, p. 136). The third complication concerns ontogenetic development, as this development is often thought to involve the emergence of both structural and functional aspects. As a fourth complication, cognitive and biological functioning are temporal developments feeding back into ontogenetic development. Thus, structural and functional aspects feed into each other and are difficult to separate; note, though, that while this reciprocity may complicate the distinction, it does not undermine it.

Why are these systematic distinctions important? We can see the reason in a recent debate over radical enactivism (REC). Moyal-Sharrock (2021) has suggested that the REC account of lower- and higher-order cognition introduces an unacceptable discontinuity between those levels. The discontinuity comes with truth-telling practices and fundamentally separates human cognition as content-involving from other

non-representational non-human forms of cognition. According to Moyal-Sharrock, for the radical embodied thesis to succeed, “we must be able to show continuity—ontogenetically, phylogenetically and logically” (Moyal-Sharrock, 2021, p. 406). But in REC we find a discontinuity between human and non-human cognition, and the discontinuity undermines the project. Myin and van den Herik (2021) respond by saying that there may be continuous development of discontinuous cognitive functions without undermining LMC:

Novel kinds of cognitive capacities can be categorically different from what was available before. Importantly, these novel capacities can give rise to functional discontinuities without there being some inexplicable jump in the processes that gave rise to those discontinuities. (Myin & van den Herik, 2021, p. 12191).

According to REC, then, higher-level cognitive abilities possessed only by humans are *functionally* discontinuous (as content-laden), but *developmentally* continuous (as acquired know-how), with lower-level cognitive abilities that humans and non-humans share. For Moyal-Sharrock, the truth of LMC requires both functional and developmental continuity. Thus, the central contention is whether that view is correct—whether LMC (or the radical embodied thesis) requires both developmental and functional continuity. Hence, misunderstandings between iterations of LMC occur because authors do not have a clear understanding of its systematic aspects.

A final complication is that LMC cuts across categorical differences between life and mind. Let us distinguish between *life–life continuity*, or continuity in living systems’ organic aspects, and *mind–mind continuity*, or continuity in the cognitive aspects of cognitive systems (cf. Bar-On, 2018). Both life–life and mind–mind continuity differ from LMC and feature their own rich theoretical traditions. For example, in the modern synthesis, life–life continuity is a doctrine of gradualism in the germ line, taken as the variations in a population’s gene frequency accumulating at large timescales and thereby yielding phylogenetic differences (Thompson, 2007, p. 170). As regards mind–mind continuity, since Darwin some have taken evolutionary continuity as indicating a psychological continuity between humans and non-humans (Darwin, 1888). This perspective has become more popular recently, with several authors claiming that the distinctive hallmarks of human cognition—communication, instrumental reasoning, metacognition, and morality, to name a few—form a continuum with non-humans (e.g., Camp & Shupe, 2017; Pepperberg, 2006; Proust, 2017; Rowlands, 2011; Zuberbühler, 2020). These claims of psychological continuity, often phrased in either comparative or phylogenetic terms, have seen much debate (Carruthers, 2019; Penn et al., 2008). LMC relates to these issues of continuity, but how it does so is not clear. LMC itself entails no specific account of either mind–mind or life–life continuity; on the other hand, any LMC-based account must clarify which continuity it operates with, if any, in these domains. In any case, what is necessary in general for LMC is that it propose some bio-cognitive continuity, understood strongly as biological principles of organization that are constitutive of the mind’s organization. With this approach, certain conceptions of continuity might be more suitable for LMC. If gradual evolution is a central biological principle, for

example, then a gradualist conception for the development of sentience might seem more plausible.

6 Towards new classifications of life–mind continuity

I have argued that we lack a distinction between the categorical, extensive, and systematic aspects of LMC. Evaluating the current formulation in terms of weak and strong continuity obscures the fact that these extensional and categorical aspects come in many varieties and can be specified relatively independently of each other. Furthermore, continuity may receive various systematic interpretations, each of which affects how we specify the categorical and extensional aspects. Research will not progress as it ought to without distinguishing these three aspects.

In this section, I provide some constructive suggestions for how to ameliorate these issues. I wish to show that the distinctions I have argued for could better classify LMC and direct us to important but under-studied research questions. To this end, I shall construct a toy-model classification catalogue based on the intersection of the extensional and categorical aspects. The model serves two purposes: first, it will illustrate a richer solution space for possible LMC-based accounts; second, the model's flaws will indicate how further research into LMC could proceed.

To construct the model, we begin by considering the ways in which life and mind could relate extensionally. We should first recognize that the two can (a) have no shared extension, (b) be partly co-extensive, or (c) be completely co-extensive. Because we are here examining cases of continuity, we shall ignore (a). Point (b) may obtain in several variations, given that we are considering two categories of phenomena. As such, I shall neglect the many possible combinations in favor of looking at only the most general possibilities. For convenience, I use the following naming scheme:

Bio-limited cognition: the extension of cognition/mind is restricted to the extension of life, and some biological phenomena occur without cognition/mind.

Psycho-limited life: the extension of life is restricted to the extension of mind, and some cognitive/mind phenomena occur without life.

Bio-cognitive co-occurrence: life and mind are completely co-extensive, such that any cognitive/mind phenomena co-occur with life (and vice versa).

These positions allow for two versions of a “subset view,” with either mind or life having the larger extension, along with the case of co-extension, which corresponds partly to what we have been calling the “entailment thesis.” Now, we must appreciate that the relationship between life and mind may be temporal, as both are temporal phenomena. Thus (b), co-extension in part, allows for temporal specifications in terms of beginnings and ends. I group these here as:

Bio-cognitive independence: the extensions of life and mind partly overlap such that either: x begins before y (x-induction), but y can remain after x ends

(y-endurance); or both x and y begin and end without co-occurring, but they do co-occur at some intermediate duration (x–y excess).

Bio-cognitive independence allows three distinct interpretations, depending on how one assigns the terms. The most popular variant seems to be the view that life begins before cognition, or “bio-induction,” but that cognition could extend beyond life, or “psycho-endurance.” Various systematic and categorical arguments could support this extensional relationship, but bio-cognitive independence as understood here offers a particular temporal perspective on life and mind’s extensional relationship. Of course, the inverse is also possible, which by my naming would be psycho-induction and bio-endurance. Lastly, it may be that life and mind begin and end independently, but still co-occur at some duration. I call this possibility “excess.”

Now let us consider the categorical relationship between life and mind. For convenience, we take one category as subordinate with the other as primary. Here I consider the shared categorical properties, where the subordinate category may have all, some, or none of the categorical properties of the primary. Let us examine the case in which it has all properties, which comes in three varieties to allow asymmetry:

Constitutive life: mind/cognition have all categorical properties of life, while life does not have all categorical properties of mind/cognition.

Constitutive mind: life has all categorical properties of mind/cognition, while mind/cognition does not have all categorical properties of life.

Co-constituted life and mind: life has all categorical properties of mind/cognition, and mind/cognition has all categorical properties of life.

The first option, constitutive life, fits well with bio-limited cognition, while the second, constitutive mind, fits well with psycho-limited life. Both are consistent with bio-cognitive independence, since the subordinate category has *all* the properties of the primary category. It therefore follows that if the subordinate exists, the primary does as well. For the same reason, co-constituted life is inconsistent with psycho-limited life—the latter entails cases of mind without life, which cannot happen if mind has all properties of life. The same holds for bio-limited cognition. We can thus conclude that co-constituted life and mind is consistent only with bio-cognitive co-occurrence. This is not a desirable result, for reasons I shall shortly cover.

Now let us consider the last two degrees of categorical commonality:

Isolation of life and mind: life has none of the categorical properties of mind, and vice versa.

Specification of life and mind: life has some of the categorical properties of mind and vice versa.

With these many extensional and categorical relationships between life and mind, I propose the following versions of life–mind relationships relevant for continuity interpretations. I also propose a name for each:

Rather than three versions of continuity, as we had before, we now have thirteen! Thus, we see how clear distinctions between categorical and extensional aspects

Table 1 A table showing versions of LMC derived from extensional commitments (top row) and categorical commitments (left column). Names are given for convenience. Cells with an x are those combinations that are impossible under the definitions provided

	Bio-limited	Psycho-limited	Bio-cognitive independence	Bio-cognitive co-occurrence
Constitutive life	Biogenic	x	x	Biobolic
Constitutive mind	x	Psychogenic	x	Psychobolic
Co-constituted	x	x	x	Reductive
Specification	Bio-specified	Psycho-specified	Intersected	Enwrapped
Isolation	Bio-enclosed	Psycho-enclosed	Tangential	Concurrent

enables finer discrimination among the possibilities. Is this a boon or a vice? I submit that these fine-grained possibilities provide clarity in reasoning about LMC. It can diagnose subtle differences between formulations and uncover hidden ambiguities. Take, for example, Godfrey-Smith's strong continuity and assume a categorical relationship of constitutive life. If the thesis allows occurrences of biological systems without cognition, then it's about biogenic continuity, and if not, then it's about biobolic continuity. This could help identify disagreement about the domain of cognitive phenomena in strong continuity approaches. Alternatively, assume categorical specification. Then it would be a claim about either biospecified continuity or enwrapped continuity. These are similar in extension to the two former iterations of strong continuity yet different in the metaphysical relationship between their candidate concepts of life and mind. This is metaphysically significant and might correspond to empirical differences. For example, assume bio-cognitive co-occurrence is true. If the candidate notion of life has the categorical property of metabolic turnover, then, on the biobolic interpretation, mind also has this property. On the enwrapped notion this is not necessarily the case. If we introduce the systematic aspects, we could further enrich our reasoning about these matters. Assume both share a functional interpretation. The two interpretations agree on the extension of bio-cognitive systems, yet they could disagree on why this extension obtains and hence the conditions for proper bio-cognitive functioning. For example, the consequences of impediments in metabolic turnover for cognitive functioning could be different. Hence, an approach along these lines might identify possible empirical differences. Once we account for systematic interpretations, temporal variations in extension, and other criteria I shall soon mention, those possibilities proliferate⁷. Although the definitions here may not

⁷ Alternatively, some might take such plentitude as a vice, and seek other solutions. I think how one perceives this matter largely depends on the theoretical goals which LMC is made to serve. In metaphysi-

be perfect, the table underscores the need for clarity regarding fundamental terms in LMC. And, yet, the catalogue is still lacking. It restricts its focus to extensional and categorical aspects while neglecting other important issues. Further research into LMC should attend to this neglect.

The most important notion neglected here is enrichment; as such, the categorical relationship is therefore framed by a binary predicate of having or not having the *same* properties. This incompleteness simplifies one of LMC's main purposes, which is to articulate the characteristic properties of mind in terms of enriched biological properties. The formulation of co-constituted life and mind is therefore problematic. The categorical relationship should instead incorporate an *asymmetry of enrichment*, in which the shared categorical properties of the subordinate category are enriched versions of those properties from the primary. Hence, the *reductive* continuity in this scheme is reductive only because it does not account for this asymmetry of enrichment. Ideally, it ought to encompass multiple accounts of continuity where the same properties are shared and yet the properties themselves differ in virtue of enrichment. And, yet, despite its crucial importance for LMC, the literature contains no account of enrichment. We notice this lack by distinguishing the extensional and categorical aspects of LMC. Describing enrichment is difficult and presents substantial metaphysical challenges. Crucially, we must explain how the *same* abstract properties encompasses *differences* through enrichment. That is an important topic for future work.

A related shortcoming of my model is that it does not consider variations in the semantics of continuity. Like enrichment, continuity has not received much explicit attention. A path forward might involve studying the meaning typically assigned to continuity in both common-sense and theoretical discourse. If we had that knowledge, we could evaluate whether a particular understanding of continuity could transfer to the context of biological and cognitive processes. Indeed, continuity is an under-explored concept, with the exception of its role in mathematics and formal theory, such as differential algebra and mereology (Bell, 2022; Hestevold, 1986). A central meaning assigned to continuity in both mathematics and in common sense is that the concept comprises non-discrete parts forming a gradual and unbroken whole with a common boundary. It is not clear whether this meaning transfers to the bio-cognitive domain, and so it is no surprise that the semantics of continuity has received no attention in the context of LMC. The most direct discussion is from Di Paolo et al. (2017, pp. 250–253), where the authors claim that LMC “entails a rejection of the sudden appearance of fully independent novel levels of description [...] without an account of how their emergence and relative autonomy are grounded on (understandable in terms of and in interaction with) phenomena at other levels” (Di Paolo et al., 2017, p. 252). This would be achieved by continuity because novel levels of description (1) are described and investigated in terms self-organization and multi-scale interaction,

cal research, this systematic cataloging helps expand the available solution-space and enables clarity of reasoning. In empirical research, things are more complicated and deserves a thorough treatment on a separate occasion. Yet the theoretical clarity afforded might still prove fruitful in empirical pursuits, perhaps in formulating hypotheses. Nevertheless, whether a systematic catalogue is pursued or not, the model shows important research questions that will further our understanding of LMC. I thank a reviewer for raising this point.

(2) have *relative* autonomy, in contrast with complete independence, where the conditions of relative autonomy are accounted for, and (3) advance inter-level interactions with evolving forms of contingencies and cross-level transformations (Di Paolo et al., 2017, p. 252). Hence, what sticks out here is the gradualness of differentiation among ontological levels, which harmonizes with Dewey's original use of the term (1938, p. 23). But important questions remain about what continuity means and how it is used by different approaches to LMC.

Another issue with my model is that it neglects systematic aspects. One approach to fixing it would take the catalogue as a declination scheme, which modifies various systematic approaches to LMC. Biogenic LMC, for example, could bifurcate into synchronic or diachronic versions, and those in turn into inter- and intra-systematic versions. Alternatively, we might give LMC's systematic aspects a more central role in cataloging potential accounts. This seems the wiser choice, because systematic approaches fundamentally alter the meaning of extensional and categorical aspects for LMC. In the case of inter-systematic approaches, the occurrences in question are entire bio-cognitive systems, while intra-systematically they would be the bio-cognitive activities, structures, and/or functions of those systems. Extension claims, such as "where there is mind there is life," fundamentally differ—in some cases they would claims about whether cognitive systems are also biological systems, but in others the meaning would be much harder to grasp. The claims might mean that cognitive episodes also (necessarily) involve biological episodes in the same system, or that any cognitive function is also a biological function. Claims about the status or capacities of an entire system differ from claims about the relationships between system activities and thus need different categorical justifications. Hence, various systematic approaches to LMC might require entirely different categorical and extensional treatments.

Lastly, a complete account of LMC must include the theoretical context, such as background notions of mind and life, along with their theoretical aims. Various instances of LMC could have different degrees of plausibility with different background notions. Furthermore, it may also be—and probably is in some situations—that different views on LMC could be reconciled based on their different notions of life and mind. A full accounting of this context would be central to any proper evaluation, formulation, and classification for LMC.

Despite these omissions, the catalogue I give here pushes us in the right direction. There are several reasons why. First, it articulates distinctions existing in the literature but not captured with the weak/strong classification for LMC. It does not, of course, exhaust those positions or their content. But given that many current views self-identify as instances of strong continuity, the catalogue does give useful heuristics for distinguishing them. Second, the catalogue outlines possible approaches to LMC that do not currently exist but whose addition would enrich our knowledge. For instance, psychobolic continuity could find justification in versions of panpsychism. Although such a position would disagree with traditional LMC accounts on the metaphysical priority of life and mind, the views would share commitments about enrichment and continuity. They could therefore collaborate to further research on those notions. The third and most important reason is that the catalogue demonstrates how rich and nuanced is the philosophical landscape of LMC. The thesis invites deep phil-

osophical reflection. There is so much work to do, and many fascinating questions to answer, toward developing a full account of LMC and the various approaches to it.

The thesis of LMC is important as a metaphysical project of naturalizing mind and cognition. In doing so, it hopes to overcome issues raised by the mind–body problem, while emphasizing that mind and cognition are distinct natural phenomena. But LMC is also a principle for empirical research: it widens the domain of investigation for biology and cognitive science and allows new methods to inquire into these domains. Hopefully, distinguishing between categorical, extensional, and systematic aspects will aid this enterprise.

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Declarations

Conflict Of interest None.

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