More hydra, than human? Moral considerability of human brain organoids based on neural architecture

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1. Background

- Human brain organoids (HBOs) are novel entities grown from stem cells with uncharacterized cognitive potential to exhibit ‘intelligent’ features
- The capacity for having *intrinsic interests*, or conscious experiences with positive or negative valence, are considered sufficient for moral status [4]
- Epistemological criteria for whether HBOs possess these morally-relevant capacities remain limited and contested
- One approach–similarity of HBOs to human neuroanatomy–has notable scientific, technical, and philosophical limitations when applied to organoid-based entities [3]

2. Central Questions

- How should we conceptualize the cognitive potential of HBOs given the variability and novelty of their information processing architecture?
- What are the moral implications of different neuronal architectures?

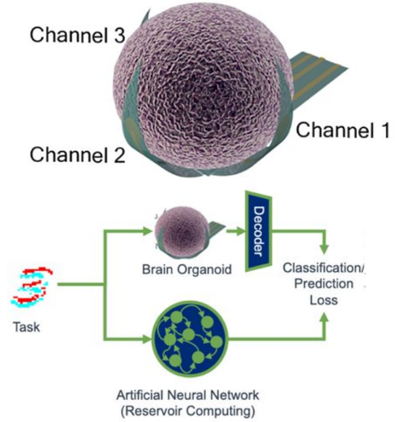


Figure 1: HBOs equipped with multielectrode arrays (MEAs), which provide and record electrical stimulation used to embody organoids within virtual environments, can be used to measure functional connectivity [5]

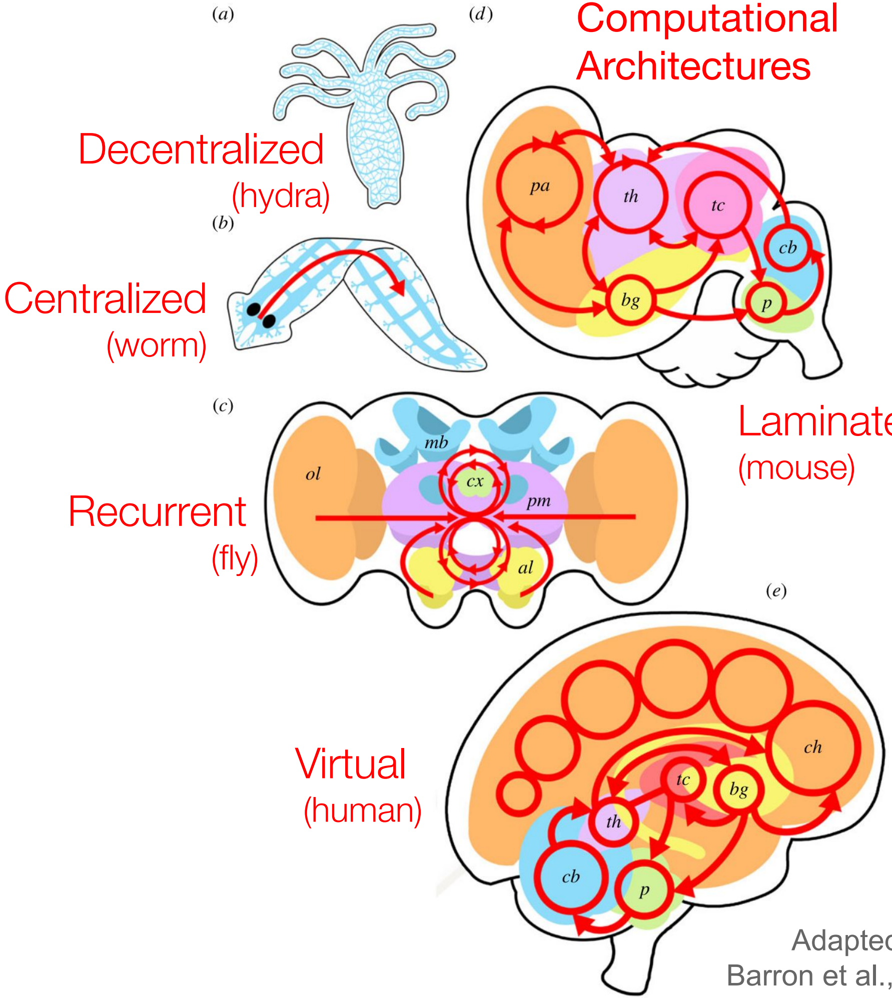
3. Main Results

3.1 Major transitions in cognitive evolution can be used to benchmark the cognitive potential of novel biological entities

- Barron’s [6] theory of transitions in cognitive evolution explicitly recognize the role of neural diversity and phenotypic potential underlying organizational principles of the brain
- Theories of information processing provide a principled approach of relating (brain) structure to function (cognition)
- Comparison of HBOs functional connectivity to Barron’s five computational architectures can provide a framework for inferring the cognitive potential of novel biological agents.
- **How should computational architecture inform moral considerability?**

Information Flow

Computational Architectures

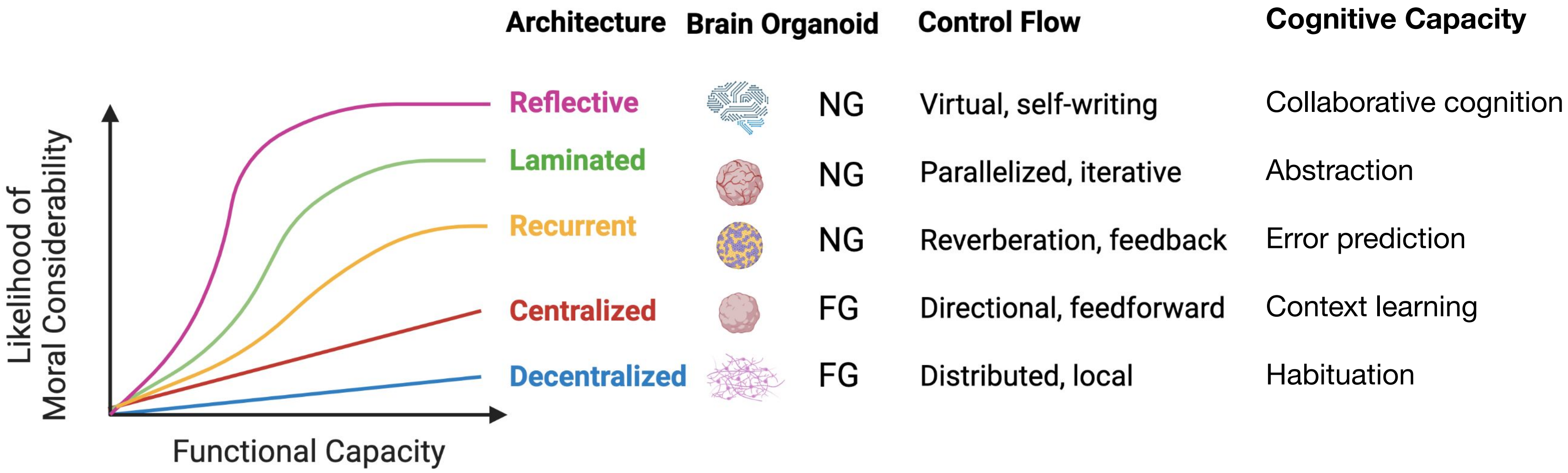


Adapted from Barron et al., 2019

3. Main Results

3.2 Moral consideration of HBOs depend on computational architecture and functional capacity

- Functional capacities, such as memory, scale at different rates depending on the underlying geometry of neuronal organization [2]
- Functional connectomes (or control flows) of first generation (FG) brain organoids are likely equivalent to decentralized architectures of the hydra, which are not known to support morally-relevant dimensions of cognition.



3.2 Main Results

3.3 Pathway toward experimental assessment of criteria underlying moral consideration [1]

Computational Architecture	Cognitive Motif	Dimension of Cognition	Moral Category
Example: Recurrent	**Example**: Temporal error prediction	**Example**: Evaluative richness	**Example:** Evaluative stance
Question: Does the neural network of the organoid exhibit feedforward and feedback control over information flow?	**Question**: To what extent does the organoids neural network support error prediction?	**Question**: Does the entity exhibit evaluative decision-making?	**Question:** What moral status is afforded sentient beings with similar information flows and evaluative decision-making?

4. Conclusions

4.1. Computational architecture provides a novel framework for discovering epistemological criteria for moral status in novel biological entities, like human brain organoids

4.2. There remains notable uncertainty regarding the ontology of cognitive capacities, including those most relevant to moral status

6. Funding

This work was supported by a grants to Lomax Boyd from the Kavli Foundation and the Johns Hopkins Whiting School of Engineering and Applied Physical Laboratory (SURPASS)

OXFORD

Oxford Open Neuroscience, 2024, **00**, kvae004
https://doi.org/10.1093/oons/kvae004
Advance access publication date 13 March 2024
Brief Perspective

Moral considerability of brain organoids from the perspective of computational architecture

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Abstract

Human brain organoids equipped with complex cytoarchitecture and closed-loop feedback from virtual environments could provide insights into neural mechanisms underlying cognition. Yet organoids with certain cognitive capacities might also merit moral consideration. A precautionary approach has been proposed to address these ethical concerns by focusing on the epistemological question of whether organoids possess neural structures for morally-relevant capacities that bear resemblance to those found in human brains. Critics challenge this *similarity* approach on philosophical, scientific, and practical grounds but do so without a suitable alternative. Here, I introduce an *architectural* approach that infers the potential for cognitive-like processing in brain organoids based on the pattern of information flow through the system. The kind of computational architecture acquired by an organoid then informs the kind of cognitive capacities that could, theoretically, be supported and empirically investigated. The implications of this approach for the moral considerability of brain organoids are discussed.

Keywords: Brain organoids, Cognition, Neuroethics, Moral status, Computational architecture, Information flow, Moral patiency.

For more detail: 10.1093/oons/kvae004

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