How does neuronal architecture shape brain dynamics?

The neuronal architecture is a primary determinant of circuit function, yet it is often simplified or overlooked in functional models. Starting from single-neuron anatomy [1], our research highlights that structural details alone are sufficient to alter circuit dynamics. Using single-cell computational models, we predict that human neurons leverage dendritic compartmentalization to optimize functional diversity, a strategy critically dependent on precise morphology.

Scaling up to the network level, we demonstrated that the physical geometry of axons (specifically non-homogeneous bouton distribution) is a primary determinant of brain-wide topology [2]. This creates a "wiring blueprint" that defines the network hubs and communities [3] that constrain whole-brain activity dynamics [4]. The fragility of this blueprint is evidenced in mouse models of intellectual disability: we found that structural perturbations, rather than just physiological over-inhibition, act as a bottleneck for network oscillations [5, 6]. Together, these findings demonstrate that neuronal architecture is an important constraint on computational capacity and pathological vulnerability.

[1] https://doi.org/10.1038/s41592-023-01848-5

[2] https://doi.org/10.1016/j.celrep.2024.113871

[3] https://doi.org/10.1038/s41592-025-02621-6

[4] https://hdl.handle.net/2445/223131

[5] https://doi.org/10.1093/cercor/bhad431

[6] https://doi.org/10.1371/journal.pcbi.1012259