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Anomalous transport in brain microvascular networks

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Blood microcirculation supplies neurons with oxygen and nutrients, and contributes to clearing their neurotoxic waste, through a dense capillary network connected to larger tree-like vessels. This complex microvascular architecture results in highly heterogeneous blood flow and travel time distributions, whose origin and consequences on brain pathophysiology are poorly understood. Here, we analyze highly-resolved intracortical blood flow and transport simulations to establish the physical laws governing the macroscopic transport properties in the brain micro-circulation (Goirand et al. Nature Communications 2021). We show that network-driven anomalous transport leads to the emergence of critical regions, whether hypoxic or with high concentrations of amyloid-β, a waste product centrally involved in Alzheimer's Disease. We develop a Continuous-Time Random Walk theory capturing these dynamics and predicting that such critical regions appear much earlier than anticipated by current empirical models under mild hypoperfusion. These findings provide a framework for understanding and modelling the impact of microvascular dysfunction in brain diseases, including Alzheimer's Disease.

Participation

In-Person

References

Goirand, F., Le Borgne, T., & Lorthois, S. (2021). Network-driven anomalous transport is a fundamental component of brain microvascular dysfunction. Nature communications, 12(1), 1-11.

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