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# Signal propagation and denoising through topographic modularity of neural circuits

*Wednesday 18 June 2025 09:00 (45 minutes)*

To navigate a noisy and dynamic environment, the brain must form reliable representations from ambiguous sensory inputs. Since only information that successfully propagates through cortical hierarchies can influence perception and decision-making, preserving signal fidelity across processing stages is essential. This work investigates whether topographic maps —characterized by stimulus-specific pathways that preserve the relative organization of neuronal populations —may serve as a structural scaffold for robust transmission of sensory signals.
Using a large modular circuit of spiking neurons comprising multiple sub-networks, we show that topographic projections are crucial for accurate propagation of stimulus representations. These projections not only maintain representational fidelity but also help the network suppress sensory and intrinsic noise. As input signals pass through the network, topographic precision regulates local E/I balance and effective connectivity, leading to gradual enhancement of internal representations and increased signal-to-noise ratio.
This denoising effect emerges beyond a critical threshold in the sharpness of feedforward connections, giving rise to inhibition-dominated regimes where responses along stimulated pathways are selectively amplified. Our results indicate that this phenomenon is robust and generalizable, largely independent of model specifics. Through mean-field analysis, we further demonstrate that topographic modularity acts as a bifurcation parameter that controls the macroscopic dynamics, and that in biologically constrained networks, such a denoising behavior is contingent on recurrent inhibition.
These findings suggest that topographic maps may universally support denoising and selective routing in neural systems, enabling behaviorally relevant regimes such as stable multi-stimulus representations, winner-take-all selection, and metastable dynamics associated with flexible behavior.

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## References

Zajzon, B., Dahmen, D., Morrison, A., & Duarte, R. (2023). Signal denoising through topographic modularity of neural circuits. Elife, 12, e77009.

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Talk (& optional poster)

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Models and applications

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