The Law of Ephaptic Information-dynamics

Aman Chawla

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Abstract

In this note the authors re-frame a prior poster result on ephaptic coupling in the language of the physical thermodynamics laws.

Consider ephaptic synchronization taking place between two axons, with differing conduction velocities. As was discussed mathematically in [1, 2] and shown via simulations in [3], the tract under ephaptic conditions acts as a greater entropy selector. That is to say the borne entropy is non-decreasing as information is processed.

Consider a network of axons coupled ephaptically and also synaptically. As information flows down this network, this observation implies that *neural information processing in isolation can only increase neural entropy.* In essence, this implies a law of ephaptic information-dynamics akin to the second law of thermodynamics in physics.

Assuming an ephaptic-synaptic setting, one of the consequences of this law is that a neural network once stimulated and then left to itself without any external interaction (i.e. operating in "isolation") will tend to a homogenous distribution of probability mass over its random variables. In particular, this means that it will not be able to carry out meaningful non-repetitive tasks.

This aligns well with the well-known importance of exposure to "rich" stimuli in early neurodevelopment. Mice that are exposed to a rich playroom for extended periods are found to have well-diversified neural arbors as compared to mice exposed to a staid environment.

If we juxtapose this result with universal quantum computation in the brain as proposed in [4], we find that the universal paradigm acts as a savior, providing a steady stream of ever-novel stimuli from across space and time to the neural system, thereby ensuring a curtailment in the growth of neural entropy.

In future work, we will explore more rigorously some of the other consequences and applications of this fundamental law.

References

[1] Aman Chawla and Salvatore D Morgera. Ephaptic synchronization as a mechanism for selective amplification of stimuli. *BMC Neuroscience*, 15(1):1–1, 2014.

[2] Aman Chawla. Neurobiophysical communication, September 2024.

[3] Aman Chawla and Salvatore Domenic Morgera. Ephaptic coupling in axon tracts under time and rate coding of information: a computer study. In *Bernstein Conference*. doi: 10.12751/nncn.bc2020.0068, 2020.

[4] Aman Chawla and Salvatore Domenic Morgera. Mechanism of universal quantum computation in the brain. *Journal of Applied Mathematics and Physics*, 12(2):468–474, 2024.