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Information flow in local cortical networks is not democratic

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The average cortical neuron makes and receives about 1,000 – 10,000 synaptic contacts. This anatomical information suggests that local cortical networks are connected in a fairly democratic manner, with all neurons having about the same number of incoming and outgoing connections. But the physical connections found in the cortex do not necessarily reveal how information flows through cortical networks. What is the network diagram for information flow in cortical networks? To investigate this issue, we recorded spontaneous spiking activity at 20 kHz for over 1 hr from organotypic cortex cultures [1] placed on a high-density 512 electrode array with 60 μm interelectrode distance. The high-density array increased the chances that we would record from synaptically connected neurons and allowed us to obtain stable long-term recordings that were essential for accurate estimates of entropy rates [2] and information flow. To measure information flow, we used a new method called transfer entropy [3] that has been shown to accurately identify connections in model networks. Our initial "democratic" hypothesis was that network diagrams of information flow would show all neurons to have approximately equal amounts of incoming and outgoing information flow. Surprisingly, our analysis revealed wide differences in the amount of information flowing into and out of different neurons in the network, indicating that information flow is not "democratically" distributed [4]. These data point to the existence of cells with high information flow that act as highly central hub nodes in the network. Future work combining experiments and simulations will be directed at exploring why local cortical networks assume such non-democratic information flow patterns.

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