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Imaging Collective Dynamics in the Neocortex

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Central to understanding collective neural dynamics is the problem of *obtaining spatiotemporal data* which reveals the collective behavior of neural ensembles; this can be done either through multi-contact recordings or through various imaging modalities. As an example of both the power and limitations of imaging techniques, we consider the onset, spread, and termination of focal seizures, imaged using the intrinsic optical signal (IOS). The IOS is a change in light reflectance from neural tissue that correlates with the underlying electrophysiological activity. With incident light in the green range, the IOS reflects changes in blood volume (CBV signal); for incident light in the orange range, the IOS shows a change in the oxygenation state of hemoglobin (Hbr signal), and can be correlated with the BOLD (blood oxygen level dependent) fMRI signal; for incident red light, the IOS reflects changes in cell volume and/or light scattering (LS signal). Using the IOS to image the spread of focal neocortical seizures induced by 4-aminopyridine in the rat, we found that the CBV, Hbr and LS signals were equally useful in localizing the ictal onset. We found a focal, profound dip in hemoglobin oxygenation (Hbr signal) during the entire seizure duration, implying that brain perfusion is inadequate to meet the metabolic demands of an epileptic focus. We observed significant variability in the spatial distribution of the active region during seizure termination. However, the IOS was unable to resolve electrophysiologically distinct patterns of seizure onset and the signal, at all incident wavelengths, persisted long after seizure termination.

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