Fast Optical Neurophysiology

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Optical imaging of neural activity allows for measuring local membrane depolarization with sub-millisecond time scale resolution. Previously, neural activation has been measured using changes in scattered light concomitant with the action potential; however, changes in light polarization are an order of magnitude larger than scattering changes. The mechanisms of polarization changes during electrical neural activity remains elusive. In order to measure the spatial components of light polarization changes concomitant with the action potential, we illuminated isolated lobster leg nerves with near infrared light (833 nm) and recorded changes in polarization using a CCD camera following stimulation. Since we wish to apply these imaging techniques in-vivo, reflection mode imaging is required. Thus, we compared the biophysical components responsible for light polarization changes from both transmitted and reflected light. Using a high sample rate, we created spatially resolved movies of action potential propagation along the nerve. We identified the temporal characteristics of the polarization changes corresponding to axon diameter and propagation speed. The spatial components of the optical signal showed a larger response at the edges of the nerve bundle in reflection mode and a larger response in the center of the nerve in transmission mode. The nerve bundle consists of several axons grouped together and surrounded by a membrane sheath. The larger edge response in reflection mode suggests the outer sheath is more reflective while the larger center response in transmission mode suggests that nerve bundle is

more transmissive.

To further investigate the source of optical changes during neural activation, future experiments include measuring the 16 parameters of the Mueller matrix during stimulation. By decomposing the elements of the Mueller matrix, we can identify the optical mechanisms such as birefringence, dichroism, and optical activity during neural activity and use these mechanisms to optimize imaging technologies.

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