In Vivo Imaging of Membrane Potential Dynamics in Populations of Ca1 Parvalbumin-positive Cells During Network Oscillaiton

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Interneurons play a critical role in coordinating network oscillation. In hippocampal CA1 area, distinct subtypes of interneurons participate in network oscillations in highly specific ways. For example, the firing of parvalbumin positive (PV+) interneurons are strongly related theta oscillation and sharp wave ripple (SWR) events. However, little is known about how interneurons coordinate among themselves during network oscillations in vivo. Here we simultaneously imaged the membrane potential in dozens of hippocampal PV+ neurons in awake, head-fixed mice using a novel voltage indicator 'Voltron'. CA1 field potential was simultaneously recorded using a tunsgen electrode. Voltage dependent fluorescence signals were imaged at ~2 kHz using a high speed camera. Fluorescence signals reflecting supra- and subthreshold membrane potential were readily observable at cellular level. The firing rates of single PV+ interneurons were modulated by both SWR and theta oscillation. SWR elicits slow subthreshold depolarizations (~50ms) in PV+ cells followed by after-hyperpolarization peaked at ~80ms after the peak of SWR. At the ensemble level, PV+ neurons display population synchrony events (PSE) in which ~30-60% of the recorded PV neurons fire synchronous action potentials within 2 ms temporal windows. During SWR, PSE events occurs in burst at ripple frequency, but nearby PSEs recruits distinct but partially overlapping PV cell ensembles. These data provide insights into the membrane potential mechanisms underlying the coordination among specific interneurons important for hippocampal circuit dynamics.

Keywords: PV+ interneuron, Voltage imaging, Sharp-wave ripple, Theta, Synchrony

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