Functional mapping of single spines in cortical neurons in vivo.

The individual functional properties and spatial arrangement of afferent synaptic inputs on dendrites have a critical role in the processing of information by neurons in the mammalian brain. Although recent work has identified visually-evoked local dendritic calcium signals in the rodent visual cortex, sensory-evoked signalling on the level of dendritic spines, corresponding to individual afferent excitatory synapses, remains unexplored. Here we used a new variant of high-resolution two-photon imaging to detect sensory-evoked calcium transients in single dendritic spines of mouse cortical neurons in vivo. Calcium signals evoked by sound stimulation required the activation of NMDA (N-methyl-D-aspartate) receptors. Active spines are widely distributed on basal and apical dendrites and pure-tone stimulation at different frequencies revealed both narrowly and widely tuned spines. Notably, spines tuned for different frequencies were highly interspersed on the same dendrites: even neighbouring spines were mostly tuned to different frequencies. Thus, our results demonstrate that NMDA-receptor-dependent single-spine synaptic inputs to the same dendrite are highly heterogeneous. Furthermore, our study opens the way for in vivo mapping of functionally defined afferent sensory inputs with single-synapse resolution.