P37

Comparison of laminar activity profiles evoked by optogenetic visual cortex stimulation using the synapsin and CamKIIα-promoter

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Transferring outside information into the brain via artificial stimulation requires tailoring the stimulation to effectively recruit local neuronal circuits. Due to its widespread activation of numerous neuronal elements, electrical stimulation struggles to achieve this goal. Optogenetic stimulation, however, allows a more fine-grained selection of the stimulation target circuit. A large part of this specificity is due to the control over the neuron type in which the light sensitive proteins are expressed. One way of defining this neuron type is via the promoter of the optogenetic construct. Here we compare two commonly used promoters, synapsin (hSyn) promoter and calmodulin-dependent protein kinase II alpha (CamKIIa) in their effectiveness to evoke a naturalistic pattern of optogenetically induced activity in primary visual cortex of mice. The primary visual cortex of wild type C57BL/6J mice was transduced with either hSyn-ChR2 or CamKIIα-ChR2 through adeno-associated virus injections. We recorded laminar local field potentials upon sensory and optogenetic surface stimulation and calculated current-source density profiles from these recordings. Our results show that optogenetic stimulation with both constructs results in activity patterns only partially mimicking the response to visual stimulation. In contrast to the hSyn group, the CamKIIa group shows a spread of the initial activity into lower cortical layers reminiscent of the natural spread of activity upon visual stimulation. This finding could be related to the co-activation of interneurons in the hSyn group, effectively blocking the spread of activity.