Patterned photostimulation of auditory cortical networks drives perceptual discrimination in mice

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Abstract

Sensory cortical areas in mammals are often organized in maps, where different stimuli activate different groups of neurons within the larger network. New optical approaches make it possible not only to image the activity of multiple neurons simultaneously in anesthetized or behaving animals, but also to manipulate this activity at arbitrary, selected spatial locations, by adressing light to the location of the chosen cells, which express light-sensitive ion channels or pumps. It is thus in principle feasible to test causally the impact of neuronal groups representing different sensory stimuli on perception and behavior. To advance towards this goal, we built a patterned photostimulation rig using an LED-based videoprojector. The optical system projects an 1280x800 pixel screen onto an area of about 2-by-3 mm, with a maximum intensity of 40 mW/mm2 for the blue LED (455 nm). This approach allows the activation of arbitrary neuronal columns across the extent of cortical areas under a chronic cranial window in mice expressing Channelrhodopsin-2 in excitatory cortical neurons.

Using this tool, we show that for mice having learnt to discriminate between two auditory stimuli in a Go-No Go licking task, the detection of the rewarded sound can be perturbed by direct activation of subregions in the auditory cortex. We also show for the first time that naive mice can learn over the course of two weeks to discriminate between the direct activation of two different regions of auditory cortex. These results demonstrate that auditory cortex activation causally influences auditory sensation in mice, and that it is possible to engineer with light discriminable artificial stimuli within a single cortical area. We are currently exploring which parameters of the optogenetic stimuli influence general aspects of auditory perception, such as saliency. We also aim at understanding what exact auditory percepts may be generated during patterned optogenetic stimulation.

Keywords: optogenetics, audition, cortex, discrimination, perception, pattern, photostimulation, channelrhodopsin, excitatory neurons

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