Photo-activation of neuronal tissue using a spatial light modulator (DMD)

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Photo-activation of excitable cells has proved to be a powerful tool to study connectivity patterns in neuronal slice tissue. Current experimental setups for the release of caged neurotransmitters or activation of transgenic cells with light sensitive ion channels employ a single light beam. In a conventional mapping experiment, an intracellular recording from a single cell in the slice is established, and the light beam is consecutively focused onto different locations within the surrounding tissue, eliciting spikes in the local cells. These spikes can be detected as postsynaptic events in the intracellular recording if a functional connection is present within the tissue, and a connectivity map can be generated from the location of light irradiation and the postsynaptic response measurement.

Single-beam based experimental systems impose certain limitations on spatial mapping experiments: the strictly sequential activation of cells limits the mapping speed, the spatial range of the maps depends on the optical properties of the microscope and objective. Moreover, the UV lasers usually used for photo-activation are expensive.

Here, we present a novel experimental setup for uncaging experiments that overcomes these limitations by employing a digital mirror device (DMD). It is used to project a spatial light pattern into the slice tissue, employing an ordinary arc lamp as light source. Our device can operate independently from the microscope optics and allows for an extremely flexible choice of stimulation parameters for each presynaptic location. In addition, the setup could also be used in dynamic stimulation paradigms and for parallel stimulation of multiple sites. Here, we explain the technical realization of the setup and demonstrate its use for the generation of connectivity maps in acute slices of neocortical tissue. Using spatial light modulators for photo-activation of neuronal tissue will open new possibilities for the investigation of connectivity and dynamic signal integration in neuronal tissue.

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