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Presentation Abstract

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Title: Strategies for practical use of multi-site optical neural control hardware in vivo

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Abstract: The ability to perturb and record distributed neural circuits is important for revealing how entire neural networks work to implement complex behaviors, and go awry in pathological states. However, the requirement for spatially-complex implants to target connected neural circuits presents unique challenges from surgical and experimental standpoints. We recently developed a scalable system for optical control of neurons in multiple sites distributed in a 3-D pattern in the brain (Bernstein et al, 2009, SFN). Here, we explore the strategies for practical use of this technology, including surgical strategies for viral delivery, craniotomy planning and performance, and fiber targeting accuracy evaluation. We also explore strategies for using this system in the context of freely moving mouse behavior.

We focused our exploration of this set of approaches, for concreteness, around a 14-element fiber-coupled LED array that targets the hippocampus bilaterally along its entire septotemporal axis, utilized in conjunction with a parallel injector array (Chan et al, JOVE, 2010) for targeting viruses to sites of interest. We developed a number of practical surgical tools and strategies to make this extensive surgery performable in a few hours or less per mouse. For example, given the need for a large number of craniotomies, all of which must be extremely precisely aligned to one another to permit multiple fiber insertion, we developed a parallelized craniotomy marking system to rapidly demarcate the sites in a single step. We also devised strategies for performing the craniotomies so as maximize accuracy and efficiency, e.g. by using fiducial markers to assist in the targeting of craniotomy drilling. Given the importance of surveying large fractions of the brain histologically, we also have partly automated the histological analysis procedure,

including semi-automated image analysis. Accuracy of implantation of the 14-fiber test array in C57BL/6 male mice (8 week old) was assessed by measuring the average deviation of the fiber tip from its intended goal, yielding deviations in the low hundreds of microns, indicating minimal tissue displacement. Finally, we demonstrate systems for conveying the power and control signals to the mouse while minimizing additional cabling weight, appropriate for behavior in spatially extended arenas such as mazes.

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Keyword(s): LED-coupled fiber array

Parallel injector array

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