A Multi-Channel Electrode for Chronic Recording and Safe Current-Steered Stimulation

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Author [a] contributed the original Matlab and LabView implementations and most of the manuscript. Author [b] performed the surgeries and histologies.

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Abstract

Long-term recording enables.... stimulation enables...

Big electrodes — effective for low-voltage stimulation, but damage going in, gliosis

Current steering — dbs: no learning control. "Adaptive" dbs, model-based coarse-grained current steering.

We show that the bundled electrodes splay in the brain.

We present preliminary results showing that these electrodes can remain capable of recording individual spikes for a year after implantation, even when also used to stimulate.

We present preliminary evidence that the spatial scale of the splaying is sufficient to allow the steering of current between the electrodes, and that this allows some degree of high-dimensional control over the brain's response to stimulation.

1 Introduction

2 Materials and Methods

2.1 Electrode construction

Electrode arrays were constructed as described in [1]. The charge transfer capacity of one of the stimulation electrodes was enhanced by electrodeposited iridium oxide. [2] describes the electrochemistry of charge transfer.

Splay histology

2.2 Zebra finch antedromic HVC $\leftarrow$ X

2.3 Recording

Recordings of spontaneous activity were done using an Intan RHD2000 amplifier.

2.4 Stimulation

We used a Plexon stimulator, and recorded using a Tucker-Davis Technologies RZ5 amplifier.

Response detection

3 Results

3.1 Chronic recording

3.2 Stimulation

Minimising stimulation voltage

Controlling the antedromic response

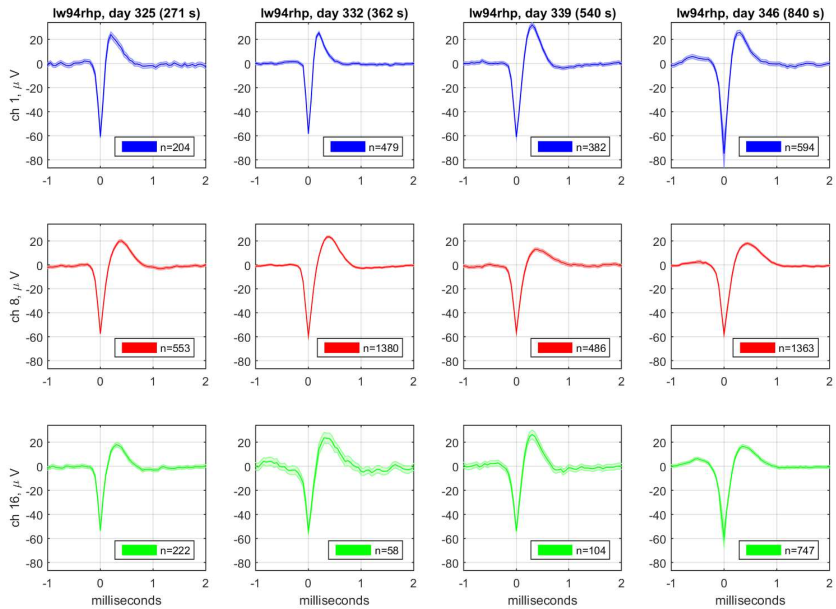

Figure 1. Some of the electrodes in Area X record spikes after nearly a year. The column titles show the day post-surgery and the number of seconds of recorded data (for bird lw94rhp). Each row is one electrode (shown here: only the three best of 16). Legends show the number of spikes; shaded region is mean $\pm$ 95% confidence.

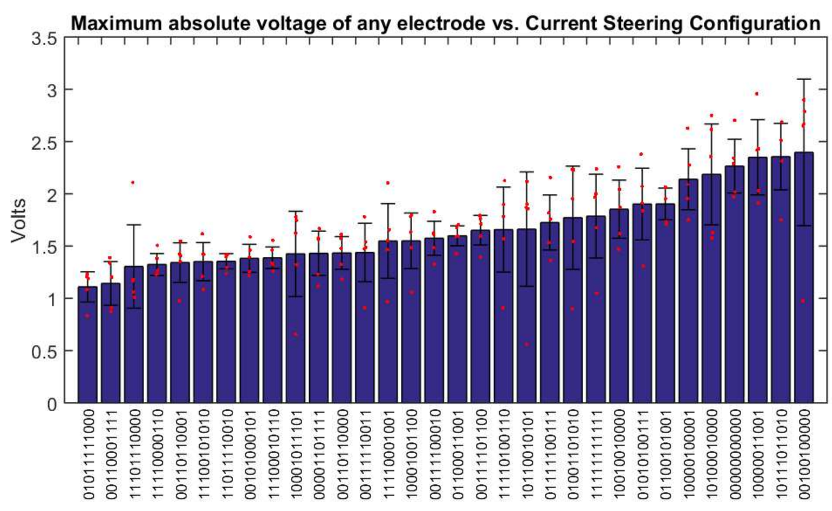

Figure 2. The peak X stimulation voltage required in order to achieve biologically effective levels of stimulation in HVC varies with different current-steering configurations. Here are 32 different configurations, over 5 trials each. The X axis lists the configuration (each of the 11 active electrodes delivers a positive-first “0” or negative-first current-controlled pulse “1” pulse). The Y axis shows the maximum voltage across any electrode. Error bars are 95% confidence intervals (n=5), and red dots are the individual trials. For some CSCs, not all trials evoked a response before our 3V threshold was exceeded, and so the true number is higher.

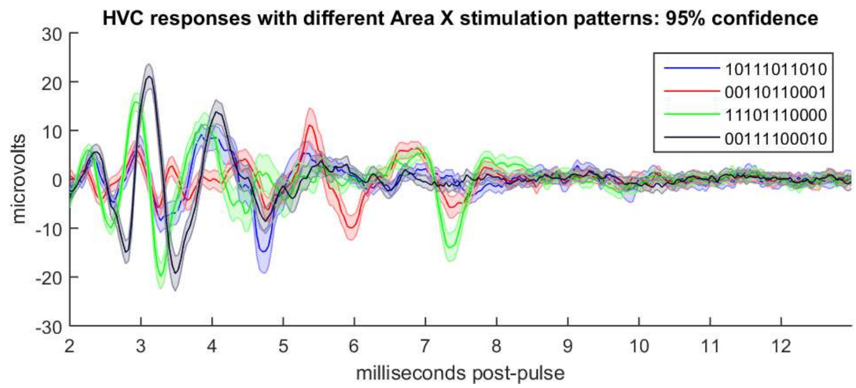

Figure 3. Different CSCs delivered to Area X can induce different responses antedromically in HVC. Here are four of the most distinct responses to four of the 32 CSCs shown in Fig. 2. Shading is 95% confidence, n=198.

4 Discussion

[3]

References

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