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Long-term stability and performance of stimulation and recording in a human participant over 2,800 days

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Introduction: The long-term stability of recording and stimulation performance of implanted electrodes is a fundamental requirement for the viability of brain computer interfaces (BCI) as clinical and assistive devices. Chronically implanted devices have documented lifetimes up to 4 years in human participants [1]; however, the timeline of device material failure [2] and stability of the underlying neural population [3] are unknown for the duration of a multi-decade participant lifetime. In this work, we show the longest reported performance data (both stimulation and recording) from four micro-electrode arrays implanted in a human participant over 0.8 decades.

Material & Methods: Over the implant duration until present time, quantitative measurements were obtained at regular intervals for each electrode individually: RMS noise, 1 kHz impedance, and SNR. We used spatiotemporal patterns of intra-cortical micro-stimulation (ICMS) to elicit naturalistic somatosensory percepts. For each electrode, we quantified participant reported descriptions (Figure 1B) and projected fields (the somatotopic location of each percept, Figure 1A).

Results: Our data shows a stable electrical interface is possible for nearly a decade of chronic implantation. For the duration of study: electrodes on 4 (of 4) arrays were still able to record single neuron waveforms (Figure 1C) and the participant was able to volitionally modulate those measured neurons via mental imagery. Nearly every electrode on 1 (of 2) stimulation arrays (SIROF) continued to elicit somatosensory percepts via ICMS (Figure 1D). Finally, not only did projected fields significantly overlap across the measured time points (suggesting robust, longitudinal stability), but the projected field also expanded with time (Figure 1A).

Conclusion: This work demonstrates current technology has the ability to effectively both record and stimulate for nearly twice as long as previously reported in the literature. These significant advances validate long term performance over multi-year BCI clinical trials.

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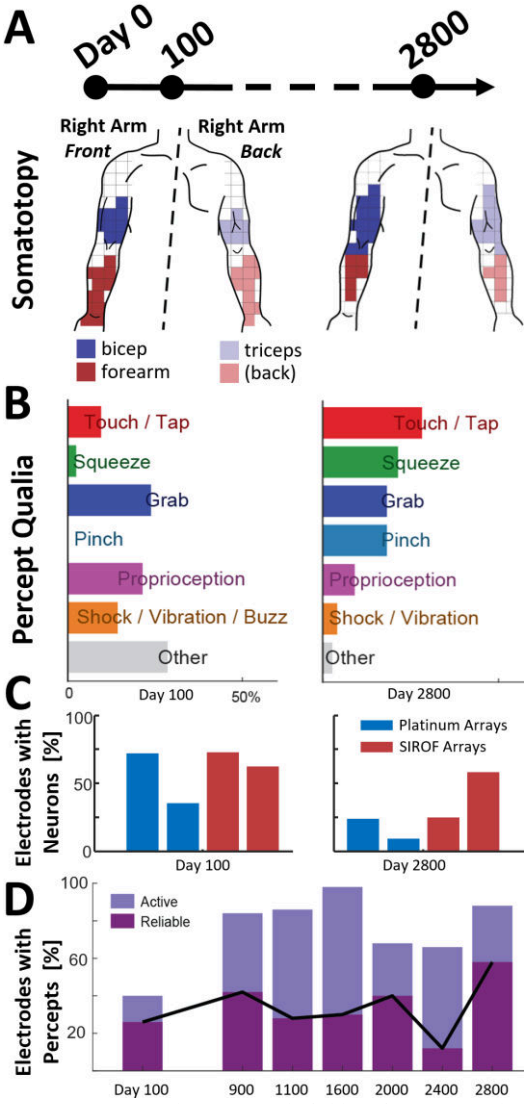

Figure 1: **(A)** *The projected fields of ICMS evoked somatosensations during the first and last timepoints. Each grid space on the body (color-coded by category) was reported from at least one electrical stimulation pattern during a survey of all implanted electrodes in sensory cortex.* ***(B)*** *Reported descriptions of evoked sensation across all electrodes, as a percentage of all reported descriptions.* ***(C)*** *Percentage of electrodes on each array which recorded single neuron activity for the first and last timepoint.* ***(D)*** *One SIROF array maintained nearly 100% of electrodes able to elicit a percept. Reliable had >67% percept rate.*

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