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Electrophysiological recording stability in human intracortical brain-computer interface users

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Introduction: The reliability of clinical intracortical brain-computer interfaces (BCIs) will depend on the stability of the neural recordings. Neural decoders will become less effective if a significant portion of the recorded population changes. In order for the BCI user to have satisfactory performance, the decoders will need to either be adjusted or completely retrained to compensate for changes in neural recordings. Here we look at recordings within and between days to determine the rate at which the units that are recorded are lost or changed, providing guidelines for how often decoders will need to be adjusted or retrained.

Material, Methods and Results: Two subjects with tetraplegia were implanted with Utah arrays and completed 2-3 BCI test sessions per week for 31 (Subject 1) and 6 (Subject 2) months. Recordings made during decoder training were used to identify units that were identically recorded in different sessions (stable units) using an algorithm that compares unit waveform shapes, firing rates, auto- and cross-correlation [1]. Additionally, within day comparisons for each subject were done based on 5 (Subject 1) and 4 (Subject 2) 7-hour recording sessions during which 8 evenly spaced recordings were made to study stability on the time scale of hours. On the time-scale of hours to days it can be assumed that an equal number of new units replace any lost units, resulting in a constant number of recorded units even as stable units disappear.

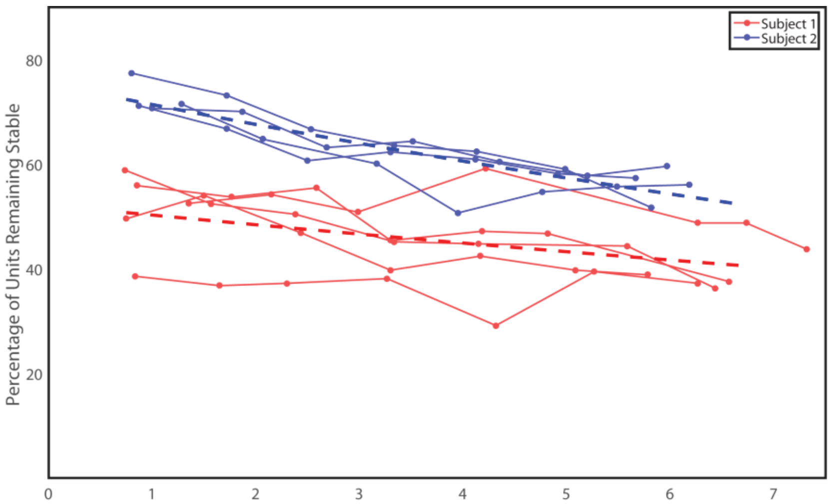

Figure 1. *The percentage of total units that remain stable across 7 hours. All 9 sessions are shown in solid lines. The dashed lines show the exponential fit for each subject. The decay rates were calculated after the large initial unit loss of primarily noisy units.*

Subject 1's recordings had an average of 29 out of 191 units remain stable for one week (33 out of 315 for Subject 2). During the 7-hour recording sessions 3.7% of Subject 1's units were lost from the recorded population every hour (5.3% for Subject 2, see Figure 1).

Discussion: These results provide a timeline for expected decoder performance decline. If a decoder only needs a small number of neurons, like the 15-unit 2D decoder from Ganguly & Carmena [2], then it could be expected to last at least a week if the BCI user has two-arrays with a similar recording quality to our subjects' and stable units can be identified in the recorded population. Identification could occur before decoder training allowing only stable units to be used. Alternatively, one could identify and exclude lost units as they drop out of the recorded population. The required number of stable units will depend on the quality of information the population provides and the necessary amount of information for the BCI tasks to be performed. These stability rates provide insight into the rate that decoders need to be updated to maintain performance.

Significance: This study provides quantification of the stability of both long and short-term intracortical recordings in 2 subjects. This data provides guidance for how often recalibration will need to be performed, which may be particularly useful as we work towards self-updating BCIs.

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