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Spectral features of EEG signals recorded from a Stentrode in human motor cortex

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Introduction: The Stentrode is a novel brain-computer interface (BCI) technology that is implanted endovascularly to measure electroencephalography (EEG) signals from the primary motor cortex. The Stentrode records field potentials, similar to intracranial electroencephalography (iEEG), although the features of these novel EEG signals have yet to be characterized fully in humans.

Methods: The Stentrode BCI system comprises an array of 16 electrodes placed on a self-expanding vascular stent[1]. To date, seven participants with severe paralysis from amyotrophic lateral sclerosis (ALS) have been implanted with the Stentrode BCI system in 2 pilot clinical trials in Australia (n = 4) and the United States (US, n = 3). Here, we present results from the first participant in the US-based trial.

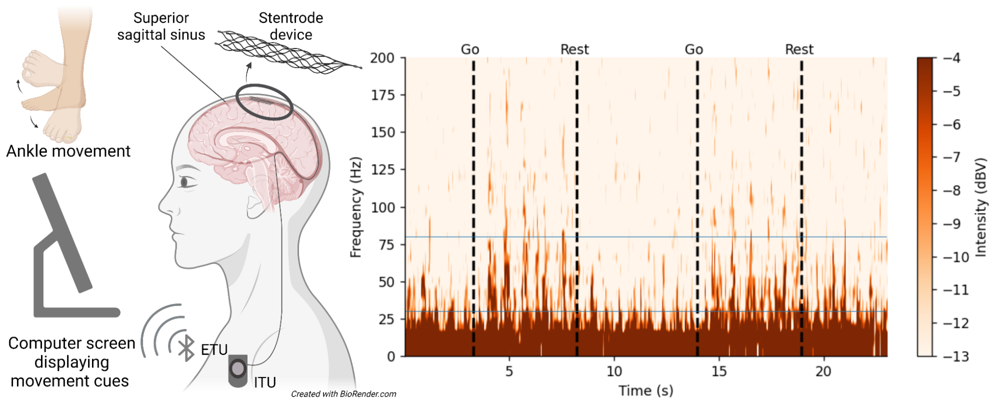

Figure 1: Schematic representation of the Stentrode implant and experimental setup. Example spectrogram for a single channel and 2 trials: The black dashed lines represent each trial (movement and rest cues). The blue lines represent the gamma frequency band where the difference between go and rest is evident.

A series of motor mapping experiments were performed to identify EEG signals that modulate with participant's attempts to move their ankles. Participants were visually cued to perform a series of 5 attempted movements in each trial. Rest periods of 5 ± 1 seconds were interleaved between trials. Here, we analyzed the EEG signals from the first US participant to identify spectral features that exhibited significant modulation during the attempted movements, as such features could be decoded to operate the BCI. We also quantified the signal-to-noise ratio (SNR) across different frequency bands. The SNR was calculated as the ratio of the mean power in each band between the movement (signal) and rest (noise) intervals.

Results and Discussion: The spectrogram in Figure 1 shows the time-frequency characteristics for recordings from a single electrode across 2 trials of attempted bilateral ankle movement. The spectrogram shows an increase in power within the beta (12-30 Hz), gamma (30-80 Hz) and high gamma (>80 Hz) frequency bands during attempted movement. The SNR was highest for the gamma gand (2.73 ± 0.07 dB), while the SNR for the beta band signal was 1.87 ± 0.06 dB. The SNR for the high gamma band signal was 1.50 ± 0.02 dB. Future work will examine the SNR across days to evaluate stability of the motor signals and identify robust and reliable features and decoding methods for performing digital communication and computer access tasks.

Significance: Following the successful completion of the first-in-human trial of the Stentrode BCI in Australia, clinical trials are now underway at 2 sites in the United States. Feature engineering is crucial for ensuring that the novel EEG signals measured by the Stentrode are classified accurately and reliably. The results reported here identified motor signals in beta, gamma, and high-gamma bands that may be useful for decoding motor intent.

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References

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