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Measuring motor intent for BCI control – a comparative analysis of the Stentrode and scalp EEG

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Introduction: The Stentrode is a novel endovascular brain-computer interface (BCI) that is implanted within the superior sagittal sinus to record bilaterally from the motor cortices. The device has enabled people with severe paralysis to gain computer control and digital communication. The Stentrode is currently undergoing an early feasibility clinical trial in the United States (NCT 05035823).

For any BCI to be viable long-term, the signals need to be high quality and remain stable over time to enable high-accuracy decoding of user intent. Multiple factors contribute to the signal-to-noise ratio (SNR) including distance to neural source, task attention, electrical contact and spacing, referencing scheme, physiological noise (such as ocular, muscular, cardiac, etc), feedback, and environmental noise. While the Stentrode sits closer to the cortex, in the absence of interceding bone, than scalp electroencephalography (EEG) electrodes and would presumably have higher signal quality, there has been no reported comparison of intravascular to scalp-based signal quality in humans.

Material, Methods and Results: Here, we explore the quality of vascular ECoG and scalp EEG signals during volitional motor attempts in one participant with paralysis due to ALS, who retains some residual movement. During two training sessions, the participant underwent simultaneous recording with the Stentrode and a scalp EEG with a standard, commercially available 64-channel gel cap. During the sessions, they were visually cued to attempt various motor tasks, such as repeated flexion and extension of the wrists and ankles. Signal quality was assessed by analyzing motor event related synchronization/desynchronization during cued movement tasks. SNR was defined as 10*log((Attempted movement band power)/(Resting band power)). The correlation between task conditions (move vs. rest) and specific frequency bands was examined via the correlation coefficients.

During attempted flexion of both ankles, the most modulated channel on the EEG cap, Cz, had a mean SNR in the beta band (13-30 Hz) of -1.69 (strong de-synchronization), while the most modulated channel on the Stentrode had an SNR of -0.43. Of particular interest is the high-gamma band (70-200 Hz), which offers rich, focal information with high utility in BCIs. In this band, the scalp EEG and Stentrode had SNRs of 0.57 and 1.95 respectively. The high SNR in the high-gamma band for the Stentrode, which doesn't face the attenuating effects of the skull, is promising for successful, reliable decoding of user intention. Data will be presented for a variety of channels, frequency bands, and referencing schemes while the participant attempts different types of movements.

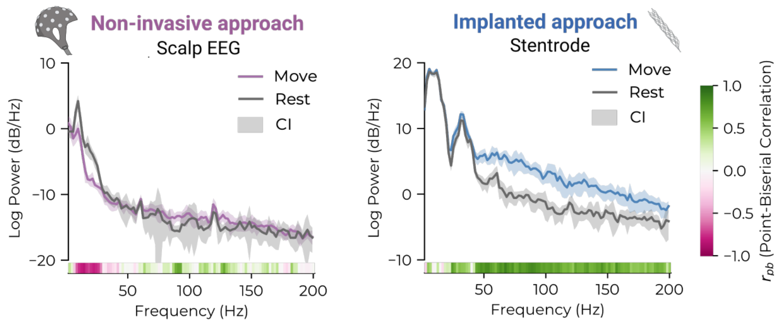

Figure 1: *Example power spectral density showing both ankle movement compared to rest for both scalp EEG (Ch Cz) and Stentrode recordings (Ch 12).*

Conclusion: Overall, the scalp EEG shows alpha and beta desynchronization during movement and post-movement beta rebound, while the Stentrode shows strong gamma synchronization. The ongoing study will continue to evaluate the signal quality and stability in multiple participants across modalities.

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