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EEG-based correlates of attention in intracortical BCI motor tasks

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Introduction: Intracortical brain-computer interface (iBCI) performance varies within and across sessions. A few studies have demonstrated that attention is one factor which can affect performance, but most have used EEG-BCI rather than iBCI and focused on simplistic tasks. To investigate the impact of attentional load on iBCI performance and the movement-related activity in motor cortex, we induced attentional load using a dual-tasking paradigm and measured the effects.

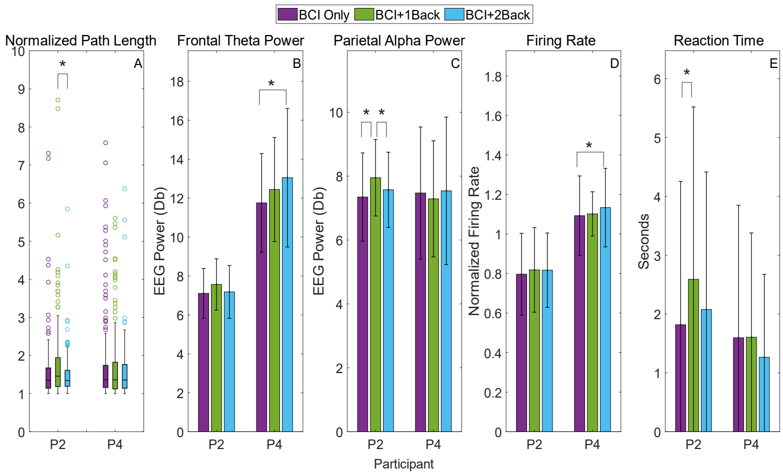

Figure 1:A) Normalized path length in P2 is highest in BCI + 1Back. B) Frontal theta power increases in both participants. C) Parietal alpha power increases in BCI + 1Back in P2. D) Firing rate increases for P4. E) Reaction time increases for P2

Materials, Methods, and Results: Two participants used an iBCI as part of a clinical trial under an FDA Investigational Device Exemption (NCT01894802). Participants performed a complex 2D computer cursor translation + click iBCI task alone (BCI Only) or paired with an N-Back (BCI + 1Back and BCI + 2Back) to induce attentional load. EEG (g.tec, 16 channels, 256 Hz sampling rate, 1-59 Hz bandpass filter) was recorded to quantify neural measures of attention including frontal region theta (3-7 Hz) power, expected to increase with attention, and parietal region alpha (8-12 Hz) power, expected to decrease with attention. BCI performance was quantified as trial completion time, normalized path length, and success rate. Performance was robust to changes in attentional load induced by the N-back with only one participant (P2) showing any significant differences across conditions, indicating iBCI's resilience to high attentional load. P2 experienced a slight increase in normalized path length in the BCI+1Back condition compared to BCI+2Back, (Fig.1**A**). Further, P2 showed increased attention, indicated by significantly higher theta and alpha band power, in the BCI+1Back condition (Fig.1**B**). Finally, P2 demonstrated slower reaction times (time to peak firing rate) in BCI+1Back compared to BCI only (Fig.1**E**). Participant P4 demonstrated increased attention (indicated by increased theta band power) (Fig.1**C**) and a higher firing rate during the BCI+2Back condition, reflecting a stronger motor signal (Fig.1**D**). Overall, P2 displayed greater changes in performance and attention compared to P4 with the BCI+1-back task combination having the greatest effect. P2 may have had more difficulty with the dual-tasking conditions because his implant duration is significantly longer than P4 (~9 years vs. < 2 years) and therefore has lower signal quality. P2 may have required more effort to maintain stable performance.

Conclusion: iBCI performance is robust to attentional load with only minor changes in performance in one participant. BCI+1Back required the most compensation for P2 as indicated by iBCI performance metrics, EEG attention signals, and reaction time estimated from intracortical firing rates. This study demonstrated the successful use of EEG to measure neural correlates of attention during iBCI performance, which provides a foundation for further exploration of BCI performance in additional participants and conditions.

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