EEG Biomarkers of Working Memory, Attention, and Fatigue

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Introduction: In this study, we evaluate the effectiveness of different workload biomarkers under distinct experimental conditions to assess their suitability in different application areas. We have worked with EEG data from three open datasets: 1) Subjects (N=14) in a short-term memory task [1]; subjects (N=36) during two different conditions: resting state and arithmetic operation performance [2]; subjects (N=27) while performing a 90-minute Virtual Reality (VR) driving task [3].

Material, Methods, and Results: A frequency-band power analysis was performed. Results showed significant increases in the theta-to-alpha ratio (TAR) with increasing cognitive demands and increased slow-to-fast ratio (SFR) at temporal areas under fatigue (see Figure 1).

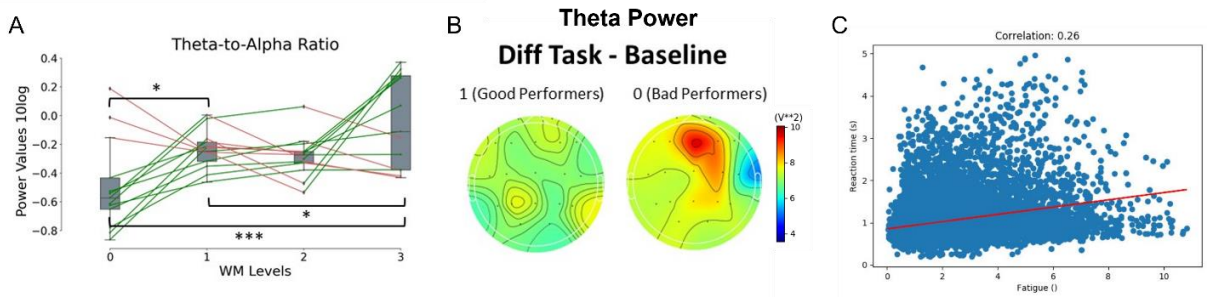

Figure 1. ***A.*** *Theta-to-Alpha Ratio computed for the EEGLearn data set [1]. Significant increases were found in response to increasing cognitive demands.* ***B.*** *Theta power topographic activity during a mental arithmetic task [2]. Bad performers showed larger values of midfrontal theta than good performers.* ***C.*** *Slow-to-fast power ratio computed at temporal electrodes during a driving task [3]: Correlation ($R = 0.26$, $p < 0.0001$) between the slow-to-fast ratio computed five seconds before lane deviation and participants' reaction time for correction.*

Discussion: We validated the theta-to-alpha ratio as a reliable working memory biomarker both during memory and mental arithmetic conditions [1,2]. Furthermore, this indicator can help to distinguish, even at the individual level, the amount of cognitive effort that a certain user needs for a particular task. In addition, we found the SFR to be a good indicator of the fatigue and alertness levels of the users in [3].

Significance: We have found evidence for using working memory, attention, and fatigue EEG markers that are flexible enough for a wide range of applications and will play an essential role in the future of passive BCI. Especially applications in Virtual Reality, User eXperience Assessment (UXA), and Ergonomics can benefit from such markers for the objective characterization of user response and performance.

References:

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