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Psychophysiological Assessment of Workload Under Varying Degrees of Demand and Controllability: A Validation Study

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The efficient execution of intended actions within the tactical athlete can oftentimes impact the overall safety and effectiveness of a mission. While the quality of human performance is known to be impacted by task demand, one dimension far less understood is the controllability of a system (e.g., flight platform responsiveness and handling qualities (HQ)). Traditionally, the assessment of system controllability has been conducted through subjective ratings, which are limited by a lack of objectivity, reliability, and reduced sensitivity to dynamic changes in human workload. Consequently, studies are lacking in the assessment of the objective brain dynamics associated with varying degrees of system controllability and their relation to subjective ratings of workload. **PURPOSE:** To further understand human operator workload and performance through the combined assessment of objective brain dynamics and subjective ratings during varying levels of task demand and controllability. **METHODS:** Fourteen subjects in the Naval Reserve Officers' Training Corps completed a compensatory tracking task under two conditions of task demand (Single-axis, Multi-axis) and three levels of HQ (Easy, Mild, Hard). Electroencephalograms (EEG) and subjective ratings (i.e., Bedford Workload Scale (BWS), NASA Task Load Index (TLX)) were recorded during and following each trial, respectively. Mental workload was computed as the ratio of the EEG theta (q) and alpha (a) power spectra. Workload comparisons were made using two-way ANOVA with repeated measures. **RESULTS:** BWS ratings were significantly lower for the Easy, compared to the Hard HQ, for both the Single- (3.43±0.35 vs. 5.36±0.4, $p<0.05$) and Multi-axis (4.5±0.49 vs. 7.21±0.42, $p<0.05$) conditions. TLX ratings were significantly lower for the Easy, compared to the Hard HQ, for both the Single- (35.86±4.45 vs. 58.7±4.23, $p<0.05$) and Multi-axis (50.73±5.13 vs. 73.55±2.95, $p<0.05$) conditions. Workload indicated by θ/α ratio was significantly lower in the Easy, compared to the Hard HQ for the Single-axis condition (0.91±0.41 vs. 1.08±0.05, $p<0.05$). Contrary to expectation, θ/α ratio was significantly higher in the Easy, compared to the Hard HQ for the Multi-axis condition (1.1±0.05 vs. 0.95±0.32, $p<0.05$). **CONCLUSION:** Challenging handling qualities significantly increased subjective ratings of workload in addition to objective brain dynamics. Future studies will examine the time-frequency elements of workload to capture the dynamic nature of the brain state with increased temporal resolution. **SIGNIFICANCE:** This study is a first step in further understanding objective biomarkers of operator workload and their relation to subjective ratings of task load and human performance; the results of which ultimately will help inform aircraft engineers in the safe and efficient design of new aircraft.

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