Workload Detection in a Closed-Loop Aegis Simulation Environment

The Aegis command and control simulated environment is a combat system with advanced, automatic detect-and-track, multi-function phased array radar. The Aegis task involved monitoring multiple data sources (i.e., missile-tracks, alerts, queries, resources), detecting required actions, responding appropriately, and ensuring system status remains within desired parameters.

The B-Alert measures of workload were evaluated while individuals acted as identification supervisors during the Aegis command and control simulation. Periods with high or extreme EEG-workload occupied between 25-30% of the scenario total time and provided a detection efficiency approaching 100% for selection-identification and alert events, 77% for hooking-tracking and 70% for queries. High or extreme workload was identified in less than 5% of the time that wasn't occupied by high-difficulty events.

This man-machine integration demonstrates the potential for utilizing physiological monitoring for the real-time assessment of operator status. Intelligent feedback or closed-loop systems can facilitate active intervention to ensure the operator remains uninterrupted during high/extreme workload periods or to increase the cognitive demand level when periods of low workload are detected.

Berka, C., Levendowski, D. et al. (2005). Evaluation of an EEG-Workload Model in an Aegis Simulation Environment. Proceedings of SPIE Defense and Security Symposium, Biomonitoring for Physiological and Cognitive Performance during Military Operations, Orlando, FL, SPIE: The International Society for Optical Engineering.

Impact of Closed-Loop Drowsiness Feedback on Driving Performance

In this application, real-time EEG classifications of engagement and drowsiness were used to trigger feedback in a closed-loop time/performance-locked driving simulator training session. In a randomized cross-over design, partially sleep-deprived subjects performed four driving simulator scenarios over an eight-hour evening period. During two of the sessions, audio feedback was initiated when EEG metrics of extreme drowsiness were detected with the intensity and duration of the feedback modulated to match changes in the EEG. Six unique sounds were selected for the alarms; the feedback sounds became more urgent each time the alarm was triggered. Performance was monitored during the other two sessions without feedback.

When feedback was provided subjects showed statistically significant improvements in reaction times and correct responses to the driving simulator divided attention task. Although there was substantial variability in driving performance resulting from sleep deprivation, the number of drifts and veers and total accidents showed significant reductions when participants were most fatigued and feedback was provided. Most participants reported that the feedback alarms were beneficial in helping them maintain alertness.

Real-time closed-loop feedback based on EEG-indices holds the potential for a number of training or safety applications. Vibro-sensory motors are currently being explored as a means to provide tactile feedback, a novel alternative to audio or visual feedback that can be generated in a confidential, non-cognitive distracting manner.

Berka, C., Levendowski, D. et al. (2005). Implementation of a Closed-Loop Real-Time EEG-Based Drowsiness Detection System: Effects of Feedback Alarms on Performance in a Driving Simulator. 1st International Conference on Augmented Cognition, Las Vegas, NV.