Use of electroencephalography and galvanic skin response in the prediction of an attentive cognitive state

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As part of an effort aimed at improving aviation safety, the Crew State Monitoring Element of the NASA Vehicle Systems Safety Technologies Project is developing a monitoring system capable of detecting cognitive states that may be associated with unsafe piloting conditions. The long term goal is a real-time, integrated system, that uses multiple physiological sensing modalities to detect multiple cognitive states with high accuracy, which can be used to help optimize human performance. Prior to realizing an integrated system, individual sensing modalities are being investigated, including the use of electroencephalographic (EEG) and galvainic skin response (GSR) signals, in the determination of an attentive or inattentive state.

EEG and GSR data are collected during periods of rest and as subjects perform psychological tests including the psychomotor vigilance test, the Mackwork clock test and the attention network test. Subjects also perform tasks designed to simulate piloting tasks within the NASA multi-attribute task battery (MATB-II) program. The signals are filtered, the artifacts are rejected and the power spectral densitity (PSD) of the signals are found. Comparisons of the PSD between the rest and test blocks are made, along with the change in PSD over the time course of the blocks. Future work includes the collection of heart rate data and the investigation of heart rate variability as an additional measure to use in the prediction of attentive state, as well as the investigation of additional EEG signal processing methods such as source localization, multi-scale entrophy and coherence measures. Preliminary results will be presented to highlight the methods used and to discuss our hypotheses.

The challenges associated with realizing a real-time, acccurate, multi-modal, cognitive state monitoring system are numerous. A discussion of some of the challenges will be provided, including real-time artifact rejection methods, quantification of inter- and intra-subject variabilities, determination of what information within the signals provides the best measurement of attention and determination of how information from the different modalities can be integrated to improve the overall accuracy of the system.