TITLE: Detection of Multiple Levels of Hypoxia through Novel Feature Analysis and Machine Learning
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INTRODUCTION: Reliable and consistent induction of cognitive impairment is important to the experimental study of performance of human operators, such as commercial aviation pilots. The specific purpose of this study was to investigate the use of normobaric hypoxia induction as a method to induce mild cognitive impairment in human operators. The current analyses presented examine the potential for improved prediction of hypoxia category, toward controlled mild cognitive impairment induced by hypoxia.

METHODS: Professional pilots served as test subjects (n=57, 49 males) in the study involving simulated altitudes of sea level (21.0% O2) and 15,000 feet (11.2% O2) induced by an Environics, Inc. Reduced Oxygen Breathing Device (ROBD). Each subject experienced both non-hypoxic and hypoxic (SPO2 <= 95%) exposures while performing three 10-minute tasks (computerized neuropsychology tests, computerized multi-tasking battery, and fixed-based flight simulation). The analyses of the physiological data (EEG, EKG, Respiratory Effort, GSR, pilot age, pilot BMI) recorded from the test subjects included statistical methods and machine learning techniques: Multinomial Logistic Regression, K-Nearest Neighbor (KNN), and Random Forest. Levels of hypoxia experienced were categorized based on peripheral SPO2 as follows for ground truth labeling purposes: completely non-hypoxic state (100-95% O2), indifferent hypoxia (95-85% O2), compensatory hypoxia (75-85% O2), and critical hypoxia (less than 75% O2). Prediction Accuracy for the four levels of hypoxia using EEG features derived from activation complexity analysis was compared to traditional spectral power analysis.

RESULTS: Analyses of features from activation complexity analysis of EEG resulted in higher classification accuracy (80.2%) of hypoxia category than features from traditional spectral power analysis of EEG (71.3% accuracy). Examining the implications of subject-specific models vs. general models of hypoxia classification indicated that accuracy was 80.2% and 51.8% respectively.

DISCUSSION: These results indicate that improved classification accuracy for determining a subject's degree of hypoxia can be accomplished using only EEG features through advanced feature engineering approaches that capture activation complexity. The contrast between classification accuracy for general models and subject-specific models indicates that models trained specifically for the test subject outperform the generally trained model. Further implications of these results, specifically analyses for classification of cognitive impairment due to the induced hypoxia, will be presented and discussed.