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CREW MENTAL STATE MONITORING IN AN EXTREME ENVIRONMENT USING FUNCTIONAL NEAR-INFRARED SPECTROSCOPY

Abstract

Future deep space exploration missions will expose astronauts to various stressors that can impair cognitive abilities and pose a risk to crew mental health and performance. Therefore, cognitive assessment strategies are needed. The assessment of cognitive state can be done by monitoring mental effort (amount of effort people have to exert mentally to perform a task). The mental effort construct assumes that task-related brain activity consumes a certain amount of mental resources that is related to the difficulty of the task, and that this resource demand can be quantified and measured. Functional near-infrared spectroscopy (fNIRS) is a non-invasive brain monitoring technology that provides a real-time blood oxygenation measure via optical intensity, thus indicating brain activation. Being easy to use, low cost, and safe for long-term and repeated measurements, fNIRS becomes increasingly important in spaceflight.

Our objective is to demonstrate the feasibility of assessing mental workload in an extreme environment by measuring brain oxygenation with a portable fNIRS device (two channels placed on the forehead).

Nine subjects were isolated for four days under extreme conditions and temperatures up to -14°C. Subjects were asked to perform a cognitive task known as the n-back task, a continuous performance task commonly used to assess memory processes and mental workload in cognitive neuroscience. Using the portable Hybrid 8-channel from Biosignalsplux, two fNIRS sensors have been placed on the left and right prefrontal cortex to measure relative concentrations of oxygenated and deoxygenated hemoglobin during the n-back task. Also, before and after the n-back task, the subjects performed a resting task (fixation cross task) to obtain baseline measurements of the brain activity.

Data have been collected successfully, and analysis is currently ongoing. A one-way analysis of variance (ANOVA) compares the effect of alteration in blood oxygenation in the prefrontal cortex during the cognitive task in comparison to the resting periods.

This preliminary study demonstrates the feasibility of using a portable fNIRS for collecting brain oxygenation measurements during cognitive task performance under extreme environmental conditions. The upcoming study in a 14- days analog mission planned for July 2022 will further challenge this promising method for monitoring mental workload during a deep space mission. The objective is to assess the effects of extreme environments, confinement, and isolation on mental workload demand to perform a high resource cognitive task by comparing pre-mission, during, and post-mission results.