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## Assessment of Mental Stress on Analog Astronauts' during Isolation and Confinement

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### Abstract

Early detection of mental stress is particularly important in prolonged space missions. In this study, we proposed utilizing electroencephalography (EEG), functional near-infrared spectroscopy (fNIRS), alpha amylase levels, and behavioral responses to detect elevated stress levels during a 240-day confinement. We quantified stress levels using alpha amylase levels, reaction time (RT) to stimuli, accuracy of target detection, and EEG power spectral density estimated by the Welch method. Our results showed that alpha amylase levels increased by 90%, 66%, 38%, 66%, and 69% after 120 days. In addition, we found that brain activity significantly increased in 80% of the subjects and decreased in 20% across all frequency bands. The behavioral data showed no significant difference over time in-mission.

**Keywords:** Stress, EEG, fNIRS, Alpha amylase, Behavioral Data

### 1. Introduction

Detecting the influence of psychological stress is particularly important in prolonged space missions. Voluntary long-term confinement can cause mental stress on participating individuals. Prolonged stress level due to long-term space missions may result in various related diseases. The effects of the space environment on human health have mainly been studied in terms of microgravity, cosmic radiations, and closed confined environments. Thus, it is very important to develop a biomarker to detect mental stress due to isolated and confined environments at its early stages. In this research, our hypothesis was that mental stress in isolated and confined environments can be assessed using behavioral and physiological biomarkers such as the electroencephalograph (EEG) and functional near infrared spectroscopy (fNIRS).

### 2. Material and methods

Five analog astronauts from different countries participated in an eight months mission. The subjects were selected by the Mohammad Bin Rashid Space Center (MBRSC), the Russian Institute for Biomedical Problems and others involved in the Scientific International Research in Unique Terrestrial Station (SIRIUS) project which started in November 2021. During the confinement period, participants conducted 2 experiments every month with a total of 18 experiments. Each experiment was for 30 minutes where participants completed a cognitive task while simultaneously acquiring their behavioral responses, salivary alpha amylase (AAL), and EEG and fNIRS signals. The amylase activity was measured using a hand-held meter (COCORO meter, NIPRO, Osaka, Japan). The EEG signals were recorded using 32 dry electrode channels covering the whole scalp and sampled at frequency of 500 Hz. The fNIRS data was collected from the frontal region using 20 channels sampled at 10.7 Hz.

Alternative signal processing algorithms and statistical analysis methods were used to analyze the collected data. In this abstract, we will only present the preliminary alpha amylase and EEG results obtained from the first nine experiments. Mental stress was assessed using the relative power spectrum density in the clinical bands, delta, theta, alpha, beta and gamma. Furthermore, statistical analysis was performed on the power spectrum data obtained during the first nine experiments.

#### 4. Results and Discussion

The obtained salivary alpha amylase level (AAL) demonstrated a sharp increase from the baseline relative to the values in experiment number 9 (after 120-days). The baseline in this study was obtained from 30 healthy control subjects. The mean baseline AAL was 11 (U/ml) while the mean AAL value of the five astronauts after 120-days of isolation was 51.4 (U/ml). In particular, we found an increase of the AAL values by 90%, 66%, 38%, 66% and 69% for subjects (1-5), respectively. The increase in AAL is consistent with our previous studies that utilized the AAL to assess the level of stress in the workplace [1], [2]. Likewise, for EEG data, we performed statistical analysis between the first experiment (in the first 14-days) and experiment number 9 (after 120-days) using two-sample t-test, per subject. We found that the brain activities have significantly increased in four subjects and decreased in one subject, subject 5. In particular, in subject 1, we found significant increase in all the frequency bands; delta ( $p < 0.009$ ) and theta, alpha, beta and gamma at  $p < 0.00001$ . In subject 2, and Subject 3 we found a significant increase in delta ( $p < 0.01$ ) and theta, alpha, beta and gamma at  $p < 0.00001$ . In subject 4, we found a significant increase in theta, alpha, beta and gamma band at  $p < 0.00001$ . Meanwhile, no significant differences were found at delta band. However, in subject 5, we found a significant decrease in theta, alpha, beta and gamma band at  $p < 0.0001$ . No significant differences were found at delta band.

The consistent increase in the EEG power spectra in all bands except the delta band for the first 4 subjects positively correlate with the AAL values. This positive correlation may indicate that subjects have experienced mental stress. On the other hand, the decrease in the EEG power spectra for subject 5 could be due to culture differences, initial training or the subject may have experienced very high stress at the beginning of the mission.

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