

# EEG neurofeedback lowers the stress reaction in psychomotor abilities execution level during analog moon mission

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### 1. Introduction

It is known how the brain will adapt to long-term travel to low Earth orbit and beyond. Perceptions of working in difficult conditions are affected by two crucial factors: motivation and stress. This could obstruct effective goal execution, as well as create stress among the people involved. The necessity appears to identify markers of differential vulnerability to changes during the prolonged isolation and the need to ensure the maintenance of circadian entrainment, sleep quality and quantity during exploration missions [1]. Successful adaptation to such conditions will require crew prepared to surface habitats that instantiate aspects of Earth's geophysical signals. It may occur in human body on many basis. Therefore, potential astronauts have to be prepared accordingly to physical, health, psychomotor aspects and have to present their crucial skills effectively and on the highest possible level in nonstandard and stressful conditions [2-5]. Stress is a process which environmental factors threaten the body's balance physiologically and mentally and affect the health of an individual under its influence. Isolation is one of the elements causing the body's increased response to a stressful situation. There is evidence that feeling of loneliness in isolation may be caused by biological, psychological, or medical factors, including the so-called stress hormones or components of the immune system, or may be correlated with them [6]. The proper functioning of a human depends not only on the physical needs of the species, such as eating and breathing, but also on the psychological needs. As humans, we have a need for acceptance, security, and emotional contact with other people. Disturbance of the possibility of contact with others, i.e., isolation, can lead to a serious dysfunction not only psychologically but also physically. Certainly, persons left to themselves, despite a possibility of survival, are in a situation that will cause them stress due to the lack of contact with another person. There is a close correlation between human stress and motivation and brain electrical activity [7]. The most common classic ways of coping with stress may be strategies leading to belonging to a given group or dedicating oneself to work. A common strategy for coping with long-term stress, e.g., at work, is to run away or avoid work. It is also known that social isolation negatively affects lipid levels and the cardiovascular system [8]. One of the methods of classical medicine is EEG neurofeedback, which enables self-control of the brain's work based on the modification of brain waves. It is a non-invasive and safe method. The basis for EEG neurofeedback is the knowledge of the brain's capabilities and the work of the nervous system, which is why it is often used also during psychiatric rehabilitation, e.g., in the fight against depression, neurosis or Alzheimer's disease. EEG test and the following changes in the activity of nerve cells during the test are influenced by external factors affecting individual senses. [9, 10]. Regarding the EEG neurofeedback method, its possibility of using it to improve memory function was investigated, among others, in patients after stroke who experienced a statistically significant improvement in working memory parameters [11]. Similar results were obtained by Campos da Paz [12] and his team, analyzing the impact of EEG neurofeedback sensorimotor rhythm training on working memory in healthy, elderly people. According to EEG neurofeedback for swimmers, the evidence has shown significant improvements in the working rates, in comparison to the control group. Also, the soccer players who have been training twice a week for four weeks with EEG, proves that the group with EEG neurofeedback finished with fewer injuries. Therefore, the muscle effects of biofeedback are inarguable and already used in professional sports. As, another example Olympic athletes that were preparing for Vancouver 2010 Olympics managed better performance due to EEG and psychophysiological stress assessment, as well as a bio-neurofeedback (BNFK) training intervention [13]. Nonetheless, this is not the only area of human activity that can implement new ways to take care of productivity and health [14]. The physiological muscle activity tends to be higher in

### 2. Material and methods

#### Participants

The participants were healthy males (10) and females (10) analog astronauts [26] taking part in analog space missions in Habitat Lunares Research Station in Pila Poland. .




Each of the subjects expressed their consent to participate in the research by letter. All study procedures were in accordance with the ethical standards of the bioethical research committee and with the 1964 Helsinki declaration and its subsequent amendments or comparable ethical standards. All subjects were healthy and without any neurological disorders. Subjects were randomly divided into control (isolation) and experimental (isolation with EEG neurofeedback groups. Experimental group age was: 26.6±6.08 where control was 23.4±2.07. The sex and personal data of the subgroup participant was unknown for the researchers.

#### Study Design and Procedure

Study design and procedure was performed based on the earlier paper establishment [5]. Defining the base level – measurement no. 1 of selected stress signatures before isolation was engaged (using psychomotor and neurophysiological evaluation). All subjects were exposed for isolation (2 weeks), EEG neurofeedback session (the ability of EEG self regulation shaping, each subject independently regulates mental states responsible for the EEG record) was implemented to the experiment group each day of the mission. After the isolation both groups have participated in the measurement no. 2 – defining the post-mission level of selected stress signatures: psychomotor and neurophysiological evaluation.

#### Psychomotor evaluation: Vienna System Test: CORSI

measures the storage capacity of spatial working memory, the Block-Tapping Test is regarded as the gold standard for testing spatial memory span. Seven parameters were taken under consideration: UBS, correct, false, omitted, sequence error, the parameter of the authoritative memory span, time of execution.

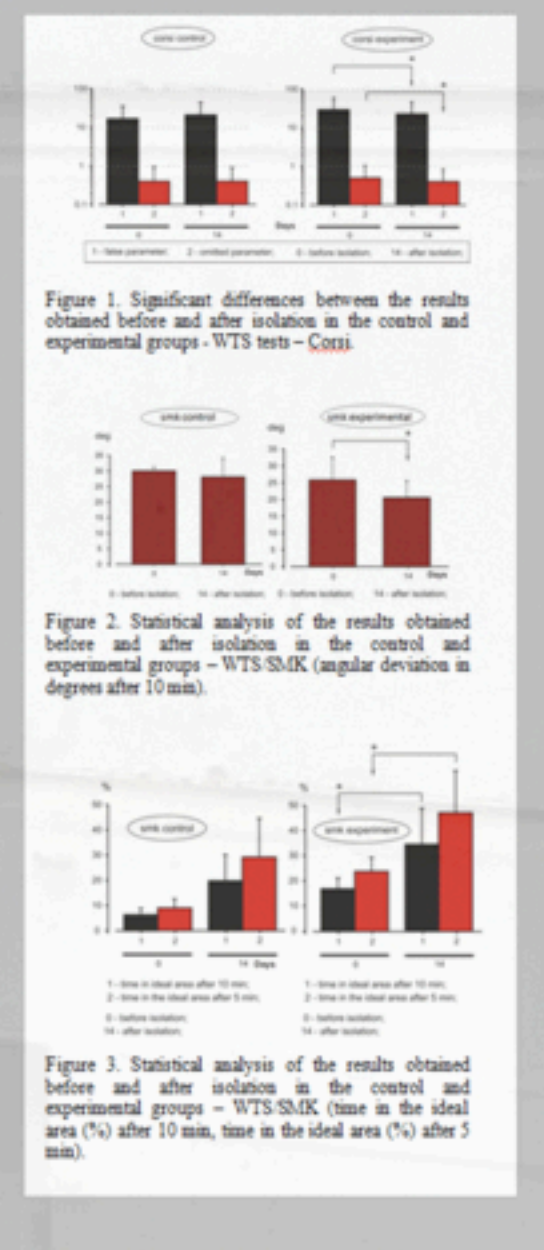
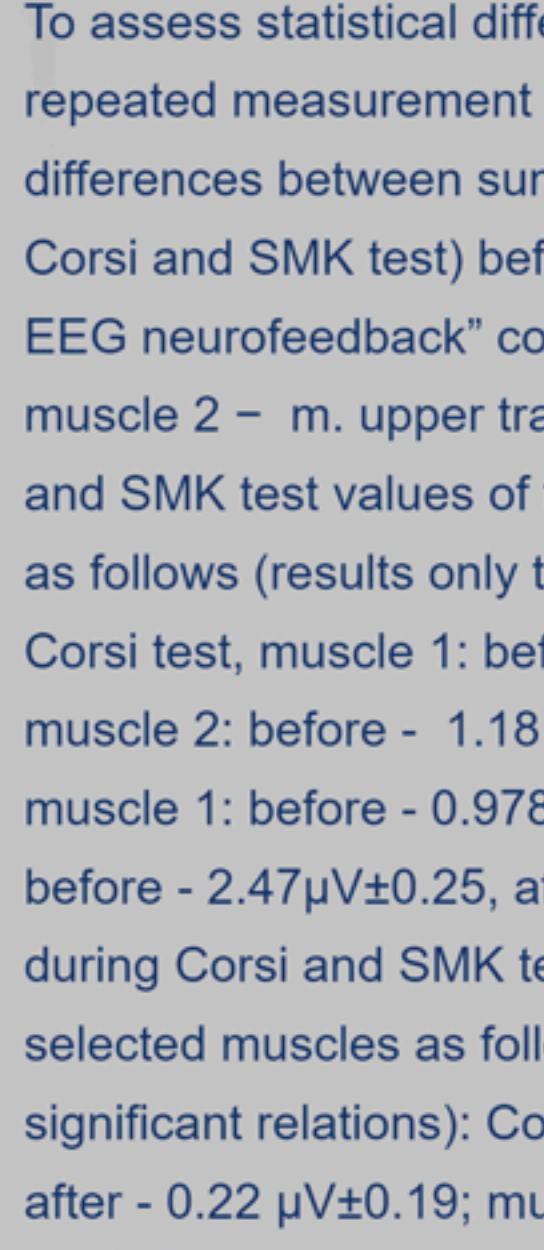
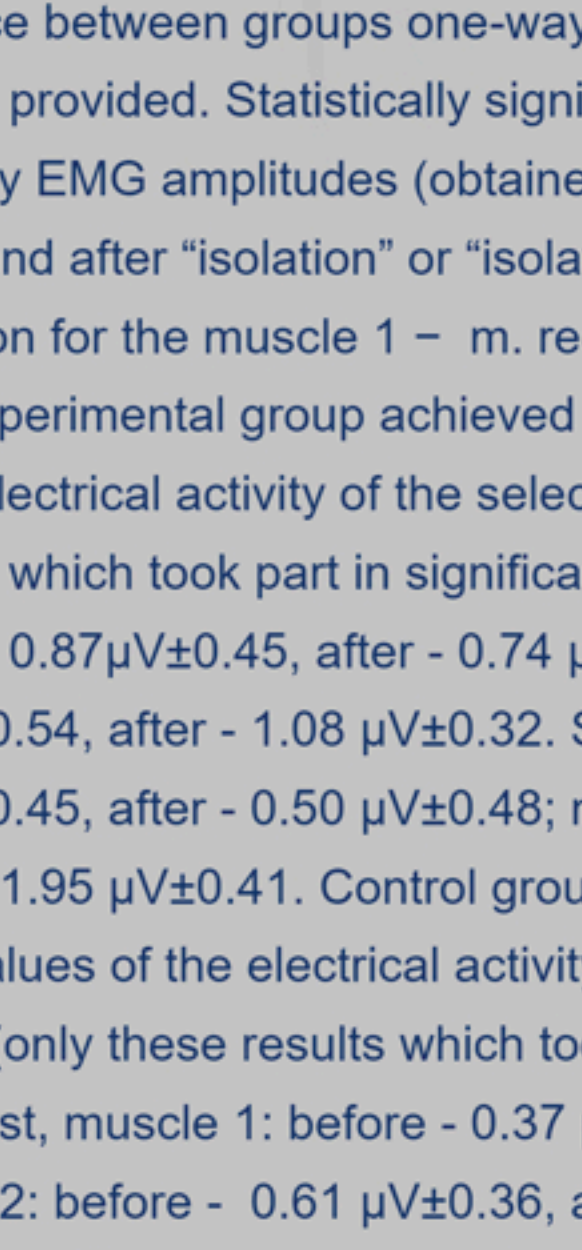


coordination test) – eye-hand, hand-hand and eye-hand-foot coordination in three-dimensional space, movements are controlled by utilizing the feedback of sensorimotor information from the movement currently being executed. Seven parameters were taken under consideration: the mean value of the angular deviation, mean value of the horizontal deviation (in pixels), the mean value of the vertical deviation (in pixels), SD of angular deflection (degrees), SD of the horizontal deviation (in pixels), SD vertical deviation (in pixels), time in the ideal area (%), time in the ideal area (%) [27].

### 3. Results

#### Psychomotor sphere

In the experimental group the values of the two examined parameters (false, omitted) of the Corsi test significantly improved after isolation with EEG neurofeedback. The results were as follows (results only those which took part in significant relations): false parameter: before - 28.83±29.55, after - 22.5±23.03; omitted parameter: before - 0.5±0.54; after - 0.4±0.44. In the experimental group the values of the three examined parameters (mean value of the angular deviation in degrees after 10 min, time in the ideal area (in) after 5 min, time in the ideal area (%) after 5 min) of the SMK test significantly improved after isolation with EEG neurofeedback. The results were as follows: angular deviation in degrees after 10 min parameter: before - 25.87±6.67, after - 20.56±4.96; time in the ideal area (%) after 10 min parameter: before - 16.75±4.34, after - 34.5±14.39; time in the ideal area (%) after 5 min parameter: before - 23.75±5.56, after - 47.16±16.77. Taking under consideration the above described selected tests parameters values achieved by control group occurred to be worse after isolation, but not statistically significant. The results were as follows (results only these which took part in significant relations): false parameter: before - 16.6±18.07, after - 20.80±23.28; omitted parameter: before - 0.4±0.54; after - 0.4±0.50. In the experimental group the values of the three examined parameters (mean value of the angular deviation in degrees after 10 min, time in the ideal area (in) after 5 min, time in the ideal area (%) after 5 min) of the SMK test significantly improved after isolation with EEG neurofeedback. The results were as follows: angular deviation in degrees after 10 min parameter: before - 30.4±1.27, after - 28.12±6.00; time in the ideal area (%) after 10 min parameter: before - 6.33±2.51, after - 19.80±10.35; time in the ideal area (%) after 5 min parameter: before - 9.00±3.60, after - 29.20±15.41 (fig. 1, 2, 3).

#### Neurophysiological sphere

To assess statistical difference between groups one-way ANOVA with repeated measurement were provided. Statistically significant differences between summary EMG amplitudes (obtained during Corsi and SMK test) before and after "isolation" or "isolation with EEG neurofeedback" condition for the muscle 1 – m. rect abdom., muscle 2 – m. upper trap. Experimental group achieved during Corsi and SMK test values of the electrical activity of the selected muscles as follows (results only those which took part in significant relations): Corsi test, muscle 1: before - 0.87µV±0.45, after - 0.74 µV±0.55; muscle 2: before - 1.18 µV±0.54, after - 1.08 µV±0.32. SMK test, muscle 1: before - 0.978µV±0.45, after - 0.50 µV±0.48; muscle 2: before - 2.47µV±0.25, after - 1.95 µV±0.41. Control group achieved during Corsi and SMK test values of the electrical activity of the selected muscles as follows (only these results which took part in significant relations): Corsi test, muscle 1: before - 0.37 µV±0.19, after - 0.22 µV±0.19; muscle 2: before - 0.61 µV±0.36, after - 0.31 µV±0.21. SMK test, muscle 1: before - 0.73 µV±0.52, after - 0.23 µV±0.21; muscle 2: before - 0.91 µV±0.23, after - 1.27 µV±0.34 (fig.4).

### 4. Discussion

During EEG neurofeedback experiment intervention almost all subjects have a decreased factor of the Alpha wave responsible for rest, relaxation and creativity, which may be related to the lack of calmness and rest. Noteworthy is the very low Alpha wave index in case of one subject (this is a symptom of exhaustion) with low alpha we have low self-esteem and weaker motivation. Earlier it was shown, that EEG neurofeedback is effective for symptom reduction in some clinical conditions (Radua et al. 2018), for example, pain [30] and attention deficit-hyperactivity disorder [31], as well as for improving motor performance after stroke [32]. Wijsman et al. [29] and Bazanova et al. [33] also showed a positive efficiency of EEG neurofeedback with EMG training in ADHD children. Enhanced muscle tone is thought to be a sign of psychomotional tension or mental stress. In our study, a decrease of m. rect abdom EMG activity can indicate some relaxation after EEG neurofeedback and thus less muscle tension in response to stress. In this case we also can speak about positive effect of EEG neurofeedback on muscle activity under isolation stress influence. The results obtained in the measurement of EMG during the SMK and Corsi tests by the control group showed the same trend. However, the values before and after the isolation turned out to be much lower. This indicates a higher level of muscle relaxation in this group before and after the mission. The aim of this study was to analyse the influence of isolation stressor on selected cognitive parameters of respondents and if those parameters changed after the implementation of the EEG neurofeedback. The results showed not only maintaining the level of tests performance but also significant positive changes in SMK (mean value of the angular deviation in degrees after 10 min parameter, time in the ideal area (%) after 10 min parameter, time in the ideal area (%) after 5 min parameter) and Corsi (false and omitted parameters) tests from VST in experimental group (EEG neurofeedback). For example, in a study [34] the authors analysed the possibility of using the EEG neurofeedback method to optimize the timing and technique of microsurgical procedures among surgeons, but the results were inconclusive. On the other hand Norouzi et al. 2018 [35] analysed the effectiveness of EEG neurofeedback training in improving the coordination abilities of children with ADHD and observed a significant improvement in motor control parameters and fewer errors in the two-handed wrist coordination test. Xiang et al. [36] in the meta-analysis pointed out that implementation of the EEG neurofeedback training among athletes significantly improved sports results. Moreover, thanks to EEG neurofeedback, one can influence the level of alpha waves and thus help a person achieve the optimal level for the functioning and maintenance of the neurophysiological and psychomotor base [37]. In work, Xiang et al. [36], the authors point out that in studies with the use of EEG neurofeedback training, a significant improvement in sports results is achieved but, in the trials, including a control group with the use of a placebo, the differences in the improvement of results are insignificant. Some authors studying the impact of EEG neurofeedback training on reaction time suggest that this intervention may be effective in improving reaction speed in players of certain sports [38], which suggests the need for further research in this area.

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### 6. Benefits in space and on Earth

Assistance on the ground in the form of psychological support is of vital importance for the tranquility of the crew members as well as for the pursuit of their personal objectives. The main benefit of the result of our experiment is an effective way in dealing with stress - lowering its effects level (using EEG neurofeedback) connected with isolation stressor and according to psychomotor areas using individually prepared EEG neurofeedback sessions performed during analog mission isolation time period.

Furthermore the identification of molecular, biochemical and psychological parameters may assist in monitoring and evaluating an individuals response to and recovery to stress environment has patent potential. The information gained from this analyses may also assist in understanding the differences between male and female responses to and recovery from stresses. Based on the achieved results we will develop the score card to evaluate the stress level on various signatures from various areas and to prescribe the intervention procedure.