Neuro-Cognitive Performance Is Enhanced During Short Periods Of Microgravity

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Introduction

In recent decades, several attempts have been made to evaluate cognitive processes in microgravity. While there is a common assumption that cognitive function is impaired in microgravity, the findings to date have been inconsistent. In an attempt to control for the stress-related effects associated with parabolic flight (Schneider et al., 2009), a primary aim of the current experiment was to compare cognitive function and any underlying neural correlates, identified by event related potentials (ERP), between 1G- and 0G-conditions during parabolic flights. If the stress related effects of parabolic flights are able to be controlled, it might be expected that brain function and cognitive performance should increase in microgravity. This may be a function of improved oxygen delivery to the brain during weightlessness (Schneider et al., 2013). We hypothesized that cognitive function would be enhanced during the microgravity phase of a parabolic flight, as indicated by improved performance during a simple to complex reaction time task. We anticipated this would also be mirrored by changes in neurocognitive markers. As these conditions are separated by <50s during the same parabola, it is likely that any differences can be attributed directly to the to changes in G-load.

Experimental Design

Participants and procedure

European Space Agency (ESA) and German Space Agency (DLR) parabolic flights take place aboard the A300 ZeroG. A parabolic flight manoeuvre is characterized by gravitational changes from 1G to 1.8G to 0G (weightlessness approx. 22 seconds, 30 experimental parabolas). During November 2010 and November 2013, data from 43 participants were recorded (female: n=13, age 35.0 +/- 8.7; male: n=31, age 39.9 +/- 9.2 years). Cognitive performance was assessed throughout the flight using an arithmetic problem solving task and EEG signals were continuously collected throughout the flight.

Cognitive task

The experimental cognitive task consisted of a mental arithmetic task (executive function) on a tablet screen with four levels of increasing complexity. Participants repeated the task at the easiest level (group EASY); and 26 participants (aged 38.5 +/- 8.4 years) performed the task with two groups: 16 participants (age 36.3 +/- 10.5 years) repeatedly performed the task at the easiest level (group EASY) and microG (solid). Group EASY (left) repeated the task at the easiest level, whereas the level was progressively increased for group DIFFICULT (right). With increasing levels of difficulty, reaction time increased. ***p<0.001 between groups performed in 0G and 1G.

EEG measurements

EEG was measured with an EEG actiCAP with 32 Ag-AgCl electrodes. EEG signals were analysed using Brain Vision Analyzer 2.0. ERPs were identified by the appearance of the task as relevant. Accordingly, amplitude (µV) as well as latency (ms) of these visual evoked potentials were exported for statistical analysis of N1 and P2.

Summary and Conclusion

This study clearly demonstrates that a decrease of cognitive performance during spaceflight as described in earlier studies is most probably not related to microgravity itself. In contrast, reaction time as well as the underlying early neural processes seem to be enhanced in microgravity. Whether this effect is caused by the initial sensation of weightlessness might be investigated repeating this experiment under permanent microgravity.

References
