Influence between motor learning and cognitive workload in microgravity

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Idea

Examine more closely the relationship between cognitive workload and motor learning in terms of resource availability and reciprocal influence in microgravity, induced by an exoskeleton.

Motivation

- Astronauts are exposed to strong stress and it is very important that they do not make mistakes during complicated repairs outside the ISS or other complex tasks involving fine motor skills
- It would be good to train motor skills in microgravity before going on a space mission, because astronauts have to adapt motorically to the conditions of microgravity
- Since all movement patterns of the human body have to be adapted or even relearned under microgravity, the connection between motor learning and cognitive load is of great importance
- Adaptation and relearning brings with it a significantly increase in cognitive load, so it would be a relief if one could start with adaptation training on earth
- Each person reacts different to cognitive load → individual measurements and calculations have to be carried out for each person

Methods

- Measure electroencephalography (EEG), electromyography (EMG) and additional physiological data (e.g. Electrocardiography, Galvanic Skin Response, Eye-Tracking, Respiration) which are in a relation to cognitive workload in simulated microgravity during a study
- Subjects are doing a primary motor learning task and a secondary cognitive workload task to reach different levels of cognitive workload
- Microgravity will be induced by the Recupera REHA exoskeleton (Fig. 1), which was investigated for rehabilitation application, but is now able to compensate its own weight and the weight of the subjects arm through an arm-model
- The success of the pretraining and adaptation mechanisms with simulated microgravity will be validated in real microgravity by means of parabolic flights

Figure 1 Recupera-REHA Exoskeleton from DFKI-RIC [1]

Background

It is necessary to prepare astronauts for the environment and microgravity in space, because they should complete the missions as successfully as possible. The technical tasks that have to be performed by the astronauts on the ISS mostly require fine motor skills. Fine motor control of the muscles for precise movements have to be adapted or relearned under microgravity. Previously electromyography (EMG) measurements have been shown that there is a reduced muscle activity when movements are performed under microgravity (both simulated and real) in comparison to Earth gravity [2,3]. Beside to the effects of motor learning on the EMG there are already results of effects on the electroencephalography (EEG). In a comparison of EEG data recorded during the performance of a simple motor task on the one hand and during a complex motor task on the other, it can be seen that θ- and α-waves occur more frequently during the complex motor task, while β-waves are seen during the performance of the simple motor task [4]. In support of this, another study found that α- and θ-waves increase with task complexity in motor tasks [5]. Cognitive workload can also be analysed on the basis of frequency bands measured with EEG. Previous studies were able to demonstrate increasing cortical activity during a parabolic flight, which is associated with increasing workload [6]. Furthermore, different states of increasing cognitive load can be shown in tasks with different levels of difficulty. In particular, in cognitively demanding tasks, the cognitive load state is significantly increased under Earth gravity [7]. How cognitive load changes under simulated and real microgravity and what influence motor learning tasks have on cognitive load states has not yet been explored. However, this is an important factor in the task and work time allocation of astronauts during longer-term stays on the ISS or possible future flights to other planets and moons. Understanding the relationships would have the added benefit of knowing about ways to prevent permanent overwork and the associated high risk of mental disorders (e.g. burnout).

Expected solutions

- **Show the relationship of the influence between motor and cognitive states** so that accidents can be prevented especially in critical areas, such as the ISS → important to keep performance and learning ability high over a longer period of time and to prevent psychological disorders such as burnout
- Development of a **software solution using machine learning methods to predict the person's cognitive load**

DLR Deutsche Raumfahrtagentur im DLR

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German Research Center for Artificial Intelligence

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