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Medicine in Space and Extreme Environments (4)

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HYPOCAMPUS - HIPPOCAMPAL PLASTICITY AND SPATIAL NAVIGATION ON THE ISS

Abstract

Adverse behavioral health and performance consequences including neurocognitive impairment are considered as one of the key challenges of long duration space missions (LDSM). Remarkably, the assessment of the neural circuitry involved with higher cognitive functions and especially spatial cognition has received little attention during spaceflight. Given the various conditions associated with spaceflight (e.g. body unloading, altered vestibular inputs, sleep and circadian disorders, isolation and confinement, radiation, increased CO2 levels), the entire brain may be prone to structural and functional changes following LDSM. A structure that could be particularly vulnerable to these stressors is the hippocampus. The hippocampus is part of the limbic system and plays important roles in learning and memory formation, and specifically spatial learning and episodic memory. Any malfunction and/or structural changes of the hippocampus could have substantial consequences on learning and memory consolidation as well as on general cognitive performance. The ESA/DLR ISS experiment HypoCampus will investigate the effects of long-duration spaceflight on the neural circuitry involved in spatial cognition. We will employ a set of cutting-edge neuroimaging techniques including ultra-high resolution hippocampal imaging and grid

cell imaging, a unique computer-based spatial assessment tool, specifically developed for long-duration space-flight that has been tested in various space analogs, and a set of biochemical markers of stress and neuroplasticity, that have been shown to provide valuable insights into the mechanisms and consequences of the expected structural and functional brain changes. These data will be compared to a control group matched for gender, age, and educational background. Critically, the science team expects that any effects will be maximally present immediately after the mission, and that cognitive recovery during the follow-up period will be related to normalization of these brain phenotypes. Finally, we will be able to compare the data with findings from over-wintering in the space analog environment of Antarctica, parabolic flight, bed rest studies, and isolation studies, as the primary outcomes (i.e. brain imaging, cognitive performance, and biochemical markers) of the proposed study largely overlap between these studies. By the end of the project, we hope to have a much better understanding of whether, to what extent, and for how long any detrimental effects on neuroplasticity and spatial cognition are induced by spaceflight. These data will provide a better understanding for the neurobehavioral changes in spaceflight, but could also provide the basis for developing target-specific countermeasure for mitigating sensory deprivation associated with long-duration exploratory space missions.