**DEEP SPACE SPACEFLIGHT HAZARDS EFFECTS ON COGNITION, BEHAVIORAL HEALTH, AND BEHAVIORAL BIOMARKERS IN HUMANS.** T. J. Williams, P. Norsk, S. Zwart, B. Crucian[2] , L. C. Simonsen[3], Erik Antonsen[5].

**Introduction:**
Spaceflight hazards have been demonstrated to both directly (i.e., space radiation, altered gravity) and indirectly (i.e., isolation and confinement, distance from Earth, hostile environment) impact on humans' neurophysiology and cognitive performance [1]. Among the specific risks are exposures to galactic cosmic radiation, toxic gases, hypercapnia, fluid shifts, sleep deprivation, chronic stress and others [2, 3]. Reports of "space fog" relate to the perception of cognitive slowing [3]. Crowding, lack of privacy, and limited sensory stimulation can all have negative impacts to human neurological and behavioral health. An additional and more unique challenge is the radiation environment in deep space, which is much stronger than that on Earth or in low-Earth-orbit. Compared to other organ systems in the body, the central nervous system (CNS) has a greatly decreased ability to repair and regenerate itsself, making it particularly at risk from radiation damage. NASA's Apollo lunar crews are the only humans with exposure in this radiation environment—but those few days of exposure do not allow us to characterize the risk associated with multi-month and multi-year missions planned for the Deep Space Gateway (DSG) and beyond. These potential hazards pose risks to the astronauts' intact neurocognitive functioning and highlight the need to systematically monitor crew performance using a comprehensive, sensitive and valid neurocognitive assessment tool. There is a need to identify the risk of both behavioral performance and cognitive perturbations caused by these stressors, in particular since space radiation guidelines pertain only to missions in Low Earth Orbit (LEO) [4]. There is a need to scientifically parse both the sources and effects of neuroinflammatory processes related to risk factors in spaceflight, identifying the biomarkers and performance measures relevant to crew performance. Missions beyond LEO offer the opportunity to identify biomarkers related to neuroinflammatory processes resulting from increased exposure to space radiation, as well as the potential compounding of oxidative and behavioral stress reactions with the other spaceflight environmental factors (e.g., microgravity, isolation). The Gateway research provides the mission-critical Deep Space proving ground for the synergistic effects of these identified spaceflight hazards.

**Methods:** The methods will leverage the biomarker detections in fluids that include stress hormones and cytokines related to neuroinflammation and brain performanace pathways. A computerized neuropsychological test battery, Cognition [1], with sensitivity in the assessment of 10 cognitive domains—including reaction time, emotion processing, spatial orientation, and risk decision making—will be used. Cognition was specifically designed for the high-performing astronaut population and is based on tests known to engage specific brain regions as evidenced by functional neuroimaging.

**Resources Required:** The Cognition Battery software must be loaded on a computer system within the vehicle, which may be a system computer or payload laptop. Crewmembers would watch a standardized familiarization video that explains software handling and each of the 10 Cognition tests before performing Cognition for the first time. During this familiarization phase, crew would be required to perform a practice version of each test before taking the actual test (available for 8 out of the 10 Cognition tests). Crewmembers will perform all 10 tests of the battery: 2 times pre-DSG Mission: L-6 months, L-3 months; weekly during DSG mission, and 2 times post-DSG mission R+14 and R+30. During the DSG mission, Cognition will be scheduled immediately prior to scheduled bed time (with some exceptions during mission-relevant demands). During pre- and post- DSG Mission testing subjects would not be allowed to perform Cognition within 1 hour after waking up (to avoid sleep intertia) or after being awake for 16 hours or more (to avoid sleep deprivation). A brief, Visual Analog Scale (identical to the survey administered on the ISS and in the ground studies in astronauts, astronaut candidates, and mission controllers) will also be administered prior to each Cognition Battery. The HRP Standard Measures will also be used to identify sleep periods and awakenings based on 60 second movement activity counts during scheduled sleep times. Datasharing of inflight biomarkers is planned to monitor and correlate neuroinflammation markers with cognition testing.

**References:**
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[4] National Council on Radiation Protection and Measurements (NCRP). Information Needed to Make Radiation Protection Recommendations for Space Missions Beyond Low-Earth Orbit; NCRP: Bethesda, MD, USA, 2006.