NASA	SPACEFLIGHT EFFECTS ON NEUROCOGNITIVE PERFORMANCE: EXTENT, LONGEVITY, AND NEURAL BASES	NEUROMAPPING

Principal Investigator

Rachael Seidler, Ph.D.

Description

During spaceflight, the control of movement is altered to account for the fundamental change in gravity. This can lead to motion disturbances and difficulty controlling motion following transitions in gravity levels (e.g., transition to Earth, lunar or Martian surfaces). Spaceflight has also been anecdotally reported to affect cognition. This investigation proposes to perform structural and functional magnetic resonance brain imaging (MRI and FMRI) to identify the relationship between changes in crewmember neurocognitive function and neural structural alterations following a six month International Space Station (ISS) mission. Our interdisciplinary approach utilizes cutting-edge neuroimaging techniques and a broad ranging battery of sensory, motor, and cognitive assessments that will be conducted pre-flight, during flight, and post-flight to investigate neuroplastic and maladaptive brain changes in crewmembers following long-duration spaceflight. Success in this endeavor would result in identification of the underlying neural mechanisms and operational risks of spaceflight-induced changes in behavior, and also identify whether a return to normative behavioral function following re-adaptation to Earth's gravitational environment is associated with a restitution of brain structure and function or instead is supported by substitution with compensatory brain processes.

Objectives

The overarching goal of this study is to quantify neurocognitive changes and associated neural structural alterations occurring as a result of a 6-month ISS mission.

Objective 1: Identify changes in brain structure, function, and network integrity as a function of spaceflight and characterize their recovery time course: Structural and functional images will be acquired at three two time points pre-flight and four time points post-flight in 13 crewmembers.

Objective 2: Specify relationships between structural and functional brain changes and performance and characterize their time course: A broad-ranging battery of sensory, motor, and cognitive assessments will be administered pre- and post-flight. A short subset of these will also be performed in-flight.

Relevance

Changes in brain structure and function may play a direct role in spaceflight-associated sensorimotor and cognitive dual task deficits, and may further impact the long-term health of astronauts, particularly in advanced age when brain volume loss and functional reorganization occur with normal human aging. NASA crewmembers may be at risk of accelerated aging effects if substantial volumetric degeneration and functional reorganization in the brain occurs during spaceflight.

BDC Summary

Each baseline data collection (BDC) session (pre- and post-flight) will consist of non-invasive brain structural and functional imaging tests in a magnetic resonance imaging (MRI) scanner as well as several laboratory tests of sensory, motor, and cognitive function. The total time for L-180 will be 3.67 hours (220 minutes) and L-60 will be 3.17 (190 minutes).
Each imaging session will require approximately 2.25 hours (135 min) including travel time to and from the off-site testing location (University of Texas Medical Branch-Victory Lakes). All neuroimaging will be performed while the subject is in the scanner.

The behavioral assessment session will require approximately 85 minutes for the L-180 session . This includes 30 minutes for the familiarization session. The L-60 session will require 55 minutes. The sessions will be conducted at NASA/JSC. The BDC battery of Behavioral Assessment tests includes a Functional Mobility Test (FMT), which requires the subject to navigate an obstacle course wearing a Body Kinematics Wearable Motion Sensor System with a harness. During the Vestibular Function Test a pure tone of 135 dB will be delivered via calibrated headphones. The other Behavioral Assessment tests are computer based tests.

Pre-flight, sessions will occur at L-180 and L-60 days. Post-flight, sessions will occur four (4) times at R+1 to R+5 days, R+30 days, R+90 days, and R+180 days. For the R+1 to R+5 BDC session, both Behavioral and Neuroimaging sessions need to be completed by R+5. Each post-flight BDC session will require 55 minutes, therefore the total time for post-flight BDC will be 3.67 hours (220 minutes). The sessions will be conduced at NASA/JSC and UTMB at Victory Lakes.

No training is required; however, there is a brief (30 minutes) familiarization session at the beginning of the first pre-flight BDC session to provide an overview of the BDC protocol as well as highlight key points for the inflight session.

NASA	SPACEFLIGHT EFFECTS ON NEUROCOGNITIVE PERFORMANCE: EXTENT, LONGEVITY, AND NEURAL BASES	NEUROMAPPING

In-flight Operations Summary

In-flight, a subset of behavioral assessment tests will be performed to complement the pre- and post-flight testing, including a mental rotation test, dual task test, and a joystick-based sensorimotor adaptation test. Three (3) in-flight sessions are required on FDs 30, 90, and 150 (flexibility +/- 10 days). Each in-flight session will require 40 minutes of crew time. In-flight sessions will utilize the existing HRF PCs and a universal serial bus (USB) joystick. Photos will be taken for documentary purposes, one session per subject (10 minutes of crew time). Data should be downlinked to the ground and delivered to the principal investigator (PI) prior to next scheduled session. Real-time downlink of data is not required for this study. In-flight medication logs will be obtained through data sharing. In addition, whenever possible, the PI would like access to data, via data sharing, of any cognitive tests performed in-flight as well as pre- and post-flight.

Subject Selection/Participation Criteria