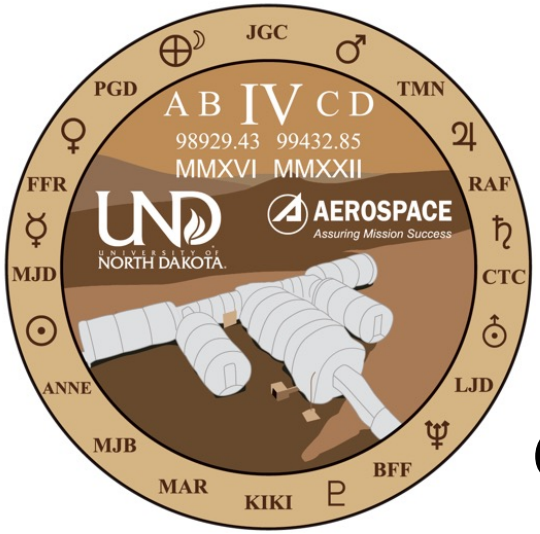
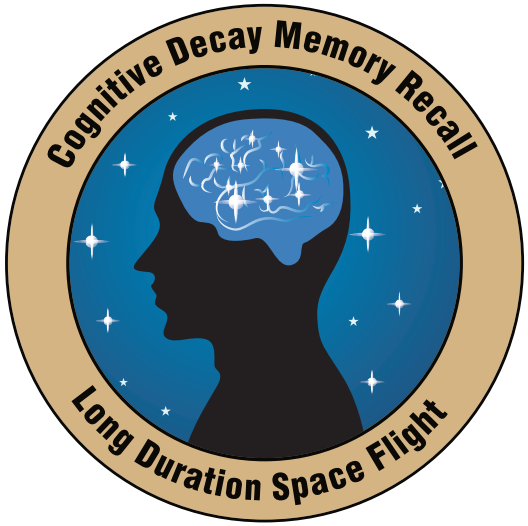


Impacts on cognitive decay and memory recall during long duration spaceflight



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Agenda

- Project Overview
- Knowledge Gap
- Research Problem
- Experiment Segments
- Research Methodology
- Experiment Realism
- Conclusions
- Sources

Photos from pilot study completed May 2021

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Project Overview

- 32-Subjects possessing similar education, experience, and skillsets will be equally divided between a treatment group and a control group tested while performing cognitive dense realistic spaceflight tasks and wearing electroencephalogram (EEG) systems to measure and characterize memory loss during simulated long-duration spaceflight (LDSF) missions comparing to Neuro-Cognitive Performance (NCP) baseline, test subjects will participate in four, 14-21 day analog missions between April 2021 through Dec 2022
- EEG data will be processed by MATLAB®, EEGLab®, eLORETA, NeuroCoach™, and SCCN neuroscience tools to develop a real-time predictive NeuroCognitive Profile (NCP)
- NCPs will be processed using IBM's SPSS v.23 in producing statistical analysis using within & between groups 2x3 repeated measures Factorial ANOVAs and MANOVA
- Findings are expected to identify when refresher training should be provided during LDSF missions

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Knowledge Gap

- As we prepare to trek beyond the confines of our Moon, NASA has identified a critical knowledge gaps including how, when and what tasks are to be trained prior too and during future long-duration spaceflight (LDSF) missions.
- NASA's seeks solutions to several Human Research Roadmap risk and knowledge gaps in the following Technology Areas (TA):
  - TA: 7.5.1 – Enhanced crew training and learning strategies and technologies
  - TA 11.3.4 – Simulation-Based Training and Decision Support System
- The knowledge increase supporting crew autonomy result from a physics imposed communications latency precluding readily available knowledge support and decision-making advice from NASA's Mission Control Center (MCC)
  - Never before in space exploration history has an orbiting crew operated fully autonomously without the MCC providing "overwatch" until now.

Research Problem

- Future LDSF will expose human crews to prolonged microgravity, Galactic Cosmic Radiation and other stresses while living and working within an Isolation, Confined & Extreme (ICE) environment.
- Such factors are expected to negatively impact the body's central nervous system, cognition, memory, and behavior.
  - The most effective process for mitigation is training
- Research is needed to comprehensively measure and model human cognitive decay and memory recall limitations in a spaceflight-realistic environment—the purpose of this research opportunity.

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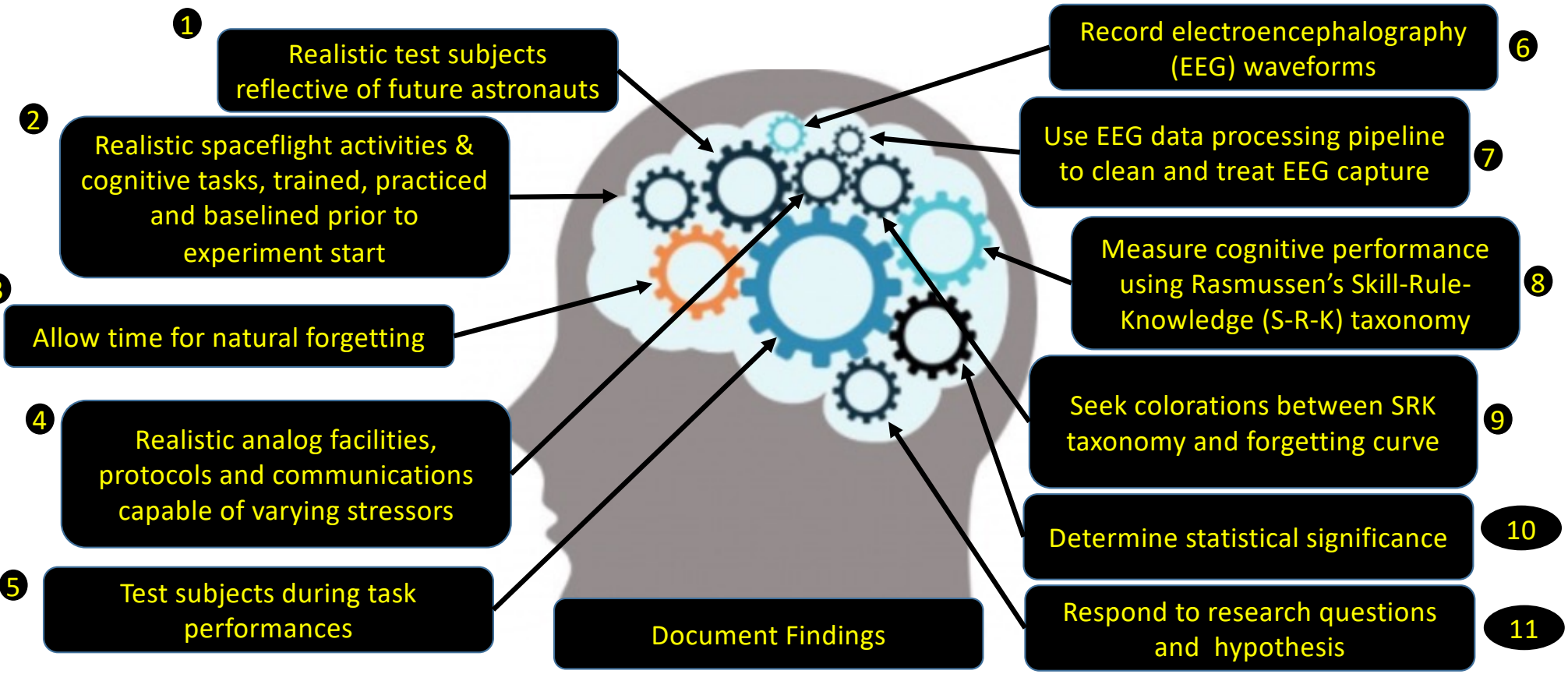
Experiment Segments



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Research Methodology

- 32-test subjects possessing similar selection traits are split evenly between experiment and control groups – each experiment includes four missions each with four subjects
- To participate subjects will respond to advertisements, interviewed and selected
- All participates will be provided training on 8 cognitive task using detailed training developed plans and procedures. Reference copies provided in crew computers.
- After training, establish EEG Neuro-Cognitive Performance (NCP) baseline
- During mission - repeat tests wearing an EEG system at varying intervals (mission time) and stress levels measuring “time to complete tasks” & “errors committed”
- Processed raw EEG data pipeline using proven open source software tools
- Questionnaires and surveys administrated before and after each test to monitor controllable and uncontrollable variables online using Qualtrics
- Mission events will occur in different order and times throughout simulations to lessen repeated measures effects

Realism - Cognitive Tasks Developed

Task	Short Title	Task Title	Task Category (Stuster, 2018 & 2019)	Time Required (min)	EEG Trials A	B	C	D	Difficulty (Nominal)	Stressed (Nominal)	Task Type (Single or Group)
C1	**TOH**	Tower of Hanoi & DSSQ	Cog/Decision Making	60	4	11	11	11	Medium	High	Individual
C2	**PRBR**	Robot/Rover Build & Repair	Robotics	60	4	6	6	6	Complex	Med	Individual
C3	**AIPI**	Artificial Intelligence Pi	Technical/Science	60	4	6	6	6	Easy	Low	Individual
C4	**DROP**	Drone Operations Outside Hab	Pilot/Robotics	90	4	5	5	5	Very Complex	Med	Either
C5	**EVAS**	EVA-Site Survey & Mapping	EVA/Planning/Intel	90	2	4	4	4	Very Easy	Med	Crew
C6	**EVAB**	EVA-Balloon Launch - Foxhunt	EVA/Science/Comms	120	2	4	4	4	Very Complex	High	Crew
C7	**EVAT**	EVA-Telescope Operations	Navigation/Cog/Comms	90	2	4	4	4	Easy	Low	Crew
C8	**EVAR**	EVA-Rescue Down Crew	Rescue/Medical/Comms	60	2	4	4	4	Complex	High	Crew
				630	24	44	44	44	156	Total	
					Testing Events						

- Tasks selected from NASA published resources
- Cognitive stressing EVA activities
- Tasks also include high altitude ballooning and piloting drone through obstacle course
- Various difficulty and stress levels
- Single and team tasks

Realism - Facilities & Equipment

- This project extends previous work, exploring the development of human models of adaptive training and neuroplasticity for Isolated Confined Extreme (ICE) environments in the Inflatable Lunar/Mars Analog Habitat (ILMAH) on the UND campus.
- With an estimated volume of 15,000^3f, the ILMAH provides an excellent resource, purposefully located for convivence and reach of resources
- ILMAH makes use of training versions of the UND developed NDX-2 planetary space suits and electric rover
- The habitat includes modules for maintenance, vegetable cultivation, physical fitness and human performance, geology research and mission control

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Wireless EEG Capture System

- Continued advances in microelectronics has provide new tools to detect and measure the brains electrical output
- Full Scalp data will be collected using a 32-channel electroencephalographic (EEG)
- The data will provide unique 3-D modelling of brain's electronic signals
  - Modelling portrays networks activations and deactivations for each task step being measured
  - The goal of this project is to corollate the SRK cognitive behaviors to individual steps by monitoring the activations and deactivations
    - Detecting information processing/decision making (cognitive decay), attentiveness, and working memory (memory decay)
    - While manipulating environmental stress
    - Measuring brainwaves provide SRK indicators

Benefits / Conclusion

- By determining cognitive decay rates, we will have a better understanding of the state of knowledge and when refresher training is truly needed
- Outcomes will help in pre-flight training design and planning as well as most effective use of training systems and simulators
- Provide supporting evidence to medical and other industries treating traumatic brain injuries and other cognitive impairment conditions
- Lastly provide similar industries with tools needed to better train their personnel Predicting cognitive decay and memory recall enables:
  - Refresher training rate prediction
  - Identification and efficient use of valuable resources
  - Tailored training for specific learning needs
  - Reduction of time and cost of initial and refresher training
  - More complex and effective training development

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