NEO – MARS ADAPTIVE TRAINING INTEGRATIVE KNOWLEDGE SYSTEM (MATRIKS) TO IMPROVE OPERATIONAL PERFORMANCE AND ITS NEURAL BASIS FOR SPACEFLIGHT

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Exploration-class missions to Mars will necessitate an increasing dependence on onboard technologies to sustain astronaut neurobehavioral functioning and performance on operationally-relevant tasks. While astronaut training is extensive, effective retention and retrieval of the operational skillset and knowledge relevant for these missions will require more than pre-mission training alone. Furthermore, limited and delayed communication will constrain support from Mission Control and crews will thus rely on autonomous technologies to successfully perform post-landing operations. To bolster astronaut neurobehavioral functioning and performance during exploration-class missions this project aims to develop and assess an adaptive, just-in-time countermeasure that can consolidate and improve skills relevant to spaceflight operations. To achieve this aim, NASA established a Virtual NASA Specialized Center of Research (VNSCOR) referred to as the "Mars Adaptive Training Integrative Knowledge System (MATRIKS)", which is comprised of the following projects: (1) "*Trinity* – Multi-Environment Virtual Training for Long Duration Exploration Missions", (PI: A. Anderson, CU Boulder); (2) "*Morpheus* – A Haptic Sensory Supplement to Optimize In-Flight Adaptive Training for Human Control of Spacecraft Robotic Arms" (PI: S. Robinson, UC Davis); and the present project "*Neo* – Adaptive Training integrative knowledge System to Improve Operational Performance and its Neural Basis for Spaceflight" (PI: C.W. Jones, UPenn).

Neo leverages the operationally-relevant and validated workstation, Six Degrees of Freedom (6DF), which simulates a rendezvous and docking maneuver using real spacecraft flight dynamics. It is designed to (1) train and improve sensorimotor skills relevant for in-flight and post-landing operational tasks; (2) feature an autonomous and adaptive training approach that does not rely on feedback from flight operations on the ground; (3) maximize the transfer of mission-relevant motor skills; (4) allow the assessment of the neural circuitry underlying the task; and (5) deliver the training in an applied and meaningful way. The *Neo* MATRIKS project consists of two overarching aims:

1. To identify the neural circuitry underlying spaceflight relevant tasks by performing a subset of 6DF tasks during functional magnetic resonance imaging (fMRI) in N=30 healthy adults with varying levels of 6DF experience.
2. To integrate the proposed 6DF autonomous intelligent tutor system in an additive manner with a haptic feedback intervention (*Morpheus*) and multi-environment virtual trainer (*Trinity*) as part of the VNSCOR MATRIKS.

It is expected that *Neo*, *Morpheus*, and *Trinity* mutually complement each other to produce an effective countermeasure tool to acquire and retain operational skills that are critical for exploration-class missions. To assess the efficacy of this combined effort, the VNSCOR MATRIKS will collect data in one 45-day HERA campaign of N=16 crewmembers (four missions with N=4 crewmembers each). The primary goal is to identify changes in operational performance, indexed by the Robotic On-board Trainer for Research (ROBoT-r), in response to MATRIKS. As part of *Neo*, we will also examine whether the effects of MATRIKS transfer to general cognitive functioning (indexed by performance on the *Cognition* test battery), distinctive visuospatial abilities critical for performing telerobotic tasks (indexed by performance on the *Spatial Cognition* battery), and brain structure and neural circuitry of key brain networks relevant for spaceflight-related performance. A total of N=30 healthy adults participated in the study conducted at DLR to identify the neural basis of spaceflight-relevant operational performance. In close collaboration with the DLR leveraging :envihab facilities, the collection of multimodal neuroimaging and performance data was completed successfully. We will present the findings from the DLR study, specifically on the neural circuitry underlying 6DF performance.

The expected significance of this project relates to its contribution to the development of effective countermeasures that facilitate the successful acquisition and retention of operational skills critical to the success of exploration-class missions.

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