

National Space Biomedical Research Institute

Team: Sensorimotor Adaptation – Team Executive Summary

Team Leader: Charles M. Oman, Ph.D.

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Background/Scope

Research addresses practical ways of mitigating functional and cognitive changes in sensorimotor function resulting from spaceflight. Currently active projects are:

1. Advanced displays for efficient training and operation of robotic systems. CM Oman, MIT.
2. Modeling and mitigating spatial disorientation in low-gravity environments. RL Small, Alion Science.
3. Development of countermeasures to enhance sensorimotor adaptation. JJ Bloomberg, Johnson Space Center (JSC).
4. Development of gait adaptability training program as a countermeasure for post-flight locomotor dysfunction. JJ Bloomberg, JSC.
5. Sensorimotor displays and controls to enhance the safety of human/machine cooperation during lunar landing. LR Young, MIT.
6. Enhancement of spatial orientation capability of astronauts on the lunar surface. R Li, Ohio State.
7. Galvanic vestibular stimulation as an analog of post-flight sensorimotor disturbance. ST Moore, Mt. Sinai School of Medicine.
8. Somatosensory suppression and prevention of post-flight reentry disturbances of posture and locomotion. JR Lackner, Brandeis.
9. Sensorimotor adaptation following exposure to ambiguous inertial motion cues. SJ Wood, JSC.
10. Research on astronaut slope and surface estimation for lunar exploration. LR Young, MIT.
11. Psychophysics and modeling of spatial orientation perception. P MacNeilage (Postdoctoral Project with D Angelaki), Washington U.
12. Investigating high-frequency vestibular function: a potential flight diagnostic. J Songer (Postdoctoral Project with D Merfeld and RA Eatock), Mass. Eye and Ear Infirmary.

Goals

As detailed in the 2007 Team Strategic Plan, NSBRI's top five sensorimotor risks and research goals are listed below, along with the NSBRI projects and intramural NASA efforts addressing them. *Proposed 2008 high priority NSBRI sensorimotor gap areas are italicized.* Corresponding NASA Human Research Program (HRP) Integrated Research Plan gap numbers are [bracketed].

1. Impaired Ability to Maintain Control of Vehicles.
 - *Develop tests to diagnose and quantify head-movement contingent vertigo, (e.g. OTTR vs Tilt Gain illusions) and determine effects on gaze control, visual acuity and manual control performance. [SM2,4,6]*
 - *Assess how changes in manual and visual function impacts ability to control vehicles. This includes assessment of returning crews and supporting ground-based studies using motion-based paradigms that simulate vehicular movement. [SM6]*

- Understand individual differences in telerobotic manual control ability, and develop methods for improving training and human interface. [SM5, SHFE4] Oman project and NASA data mining.
 - Assess sensorimotor origins of Shuttle and Shuttle Training Aircraft landing variability and correlate with neurovestibular data. [SM5] NASA data mining and Small project.
 - Develop methods for simulating landing disorientation, and train crews to fly through them. [SM11] Wood, Moore and Young projects.
 - Compile data on causes and operational impacts of extravehicular activity (EVA) disorientation and propose countermeasures. [SM11], Li project and Oman's 2003-2006 NSBRI project.
 - Develop math models to predict lunar and Mars landing disorientation. [SM5] Small and MacNeilage projects.
 - Define required cues for manual control and situation awareness during lunar and Mars landings, and the displays and controls to ameliorate problems. [SM11, 12, SHFE1, 4] Young landing, Young slope estimation, and Wood projects.
2. Impaired Ability to Perform an Emergency Egress from Soyuz or Crew Exploration Vehicle (CEV) Following Return to Earth after Long-Duration Spaceflight.
Understand how sensorimotor alterations contribute to impaired CEV functional egress on land or water rafts after long-duration spaceflight. [SM2]
- *Develop improved field tests to assess early (R+0) alterations in gaze, posture and locomotor performance that predict decrement in functional performance related to operational activities.* [SM13, 15, 16, 17]
 - Assess functional performance of returning Shuttle and ISS crews in simulated tasks and relate the physiological changes associated with spaceflight. [SM2, 7, 4] functional task test development in Bloomberg lab.
 - Improve exercise and rehabilitation protocols using adaptability training strategies and strength-balance techniques. [SM3, 16, 17] Bloomberg project, Lang project (Bloomberg, Co-I) NASA ACERs, JSC HRP Exercise Countermeasure Project.
 - Determine the impact of current in-flight exercise routines on post-flight postural and locomotor performance of long-duration ISS crews. [SM1, 15, 17, M1, 8, 9] NASA and Russia's Institute for Biomedical Problems data mining.
 - Develop locomotion and balance tests for lunar and Mars outposts suitable for clinical evaluation, fitness for EVA, and 1/5 G research. [SM7, 13, 15, M3]
3. Motion Sickness
- Identify and evaluate new prophylactic anti-motion sickness drugs. [PH7] (Putcha 2004-2008 intranasal scopolamine project; mutual NIH-NIDCD area of interest, per Dr. C. Platt.
 - Improve training on motion sickness prevention and management for astronauts and commercial spaceflight participants.
 - Quantify effect of intramuscular promethazine and oral phendex on space motion sickness incidence, symptom level and crew productivity. [PH10, CV6] NASA data mining (Locke)

- Quantify and distinguish “sopite syndrome,” “space stupids,” drug side effects and mission impact via cognitive testing. [PH10] (Putchu 2004-2008; NASA BHP team, also Ames/Welsh)

4. Artificial Gravity (AG)

- Determine AG regimen appropriate for Mars transit, and AG research agenda for lunar outpost. (2003-2007 JSC AG project; IAF and IOM committees)

Support of NASA Needs

The 2008 portfolio is well matched to NSBRI’s Strategic Plan and current HRP requirements.

Deliverables

See list of risks and goals above. Diagnostic tests, countermeasure training procedures, robotics and cockpit displays, rehabilitation and AG regimens, math models, basic physiological knowledge.

Cross-Links

Many NASA investigators are on this NSBRI Team. Oman Teleoperation and Young Lunar Landing projects are managed by JSC Behavioral Health and Performance.

Enabling Capabilities and Gaps

See topics in italics above.

Earth-Based Benefits

Studies provide basic knowledge relating to dizziness and balance problems affecting 90 million Americans, particularly the elderly. Falling is the leading cause of accidental death for persons over age 75 and is responsible for 40 percent of nursing home admissions.