

The Effects of Long Duration Head Down Tilt Bed Rest on Neurocognitive Performance: Extent, Longevity, & Neural Bases

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Background & Justification

- Spaceflight effects on gait, balance, & manual motor control have been well studied; some evidence for cognitive deficits
- Rodent cortical motor & sensory systems show neural structural alterations with spaceflight
- What about neural structural changes in humans?

Aims of the two projects

- Aim 1- Identify changes in brain structure, function, and network integrity as a function of prolonged head down tilt bed rest / spaceflight and characterize their time course.
- Aim 2- Specify relationships between structural and functional brain changes and performance and characterize their time course.

Evaluating neurocognitive changes occurring with bedrest

~BR- 12

~BR-7



~BR7

~BR50

BR+0 or +1

~BR+6

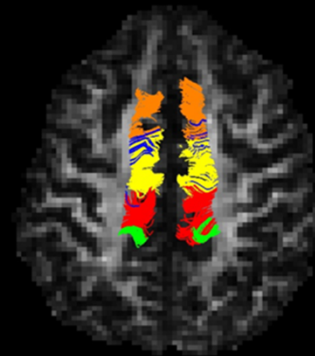
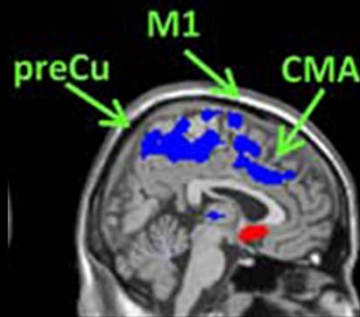
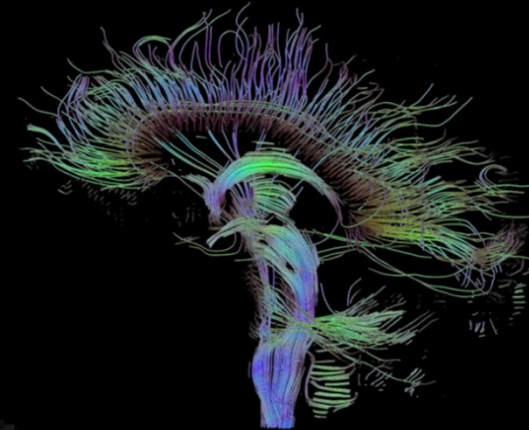
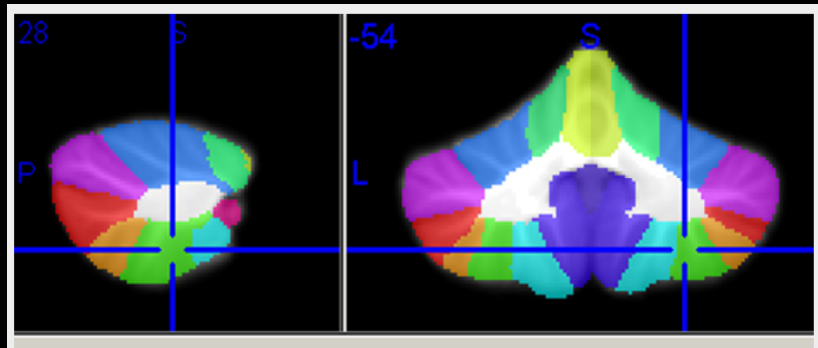
~BR+13



Conduct most behavioral & MRI assessments in ~last 5 days of BR, first session post BR = postural assessments only (SOT, FMT)



Pre & post flight; pre, during & post bedrest tests: MRI, DWI, fcMRI



Fling et al. 2013 Human Brain Mapping
Fling et al. 2012 Cerebral Cortex
Fling et al. 2011 Journal of Cognitive Neuroscience
Kwak et al. 2010 Frontiers in Systems Neuroscience
Langan et al. 2010 Frontiers in Systems Neuroscience
Fling et al. 2011 Frontiers in Neuroscience

Pre & post flight; pre, during & post bedrest tests: functional MRI

Task-based functional MRI (fMRI): brain networks engaged to perform various tasks

- Click / head tap induced VEMP (vestibular cortex mapping)
- Single & dual tasking of cognitive-motor tasks
- Sensorimotor adaptation task
- Spatial working memory task
- Foot tapping



Kwak et al. 2012 Behav Brain Research

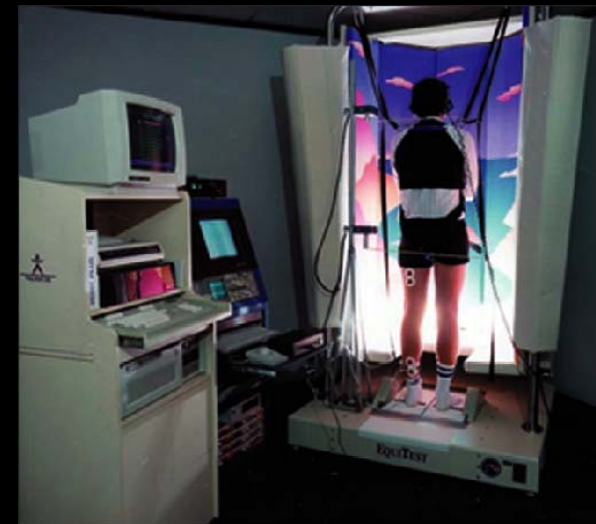
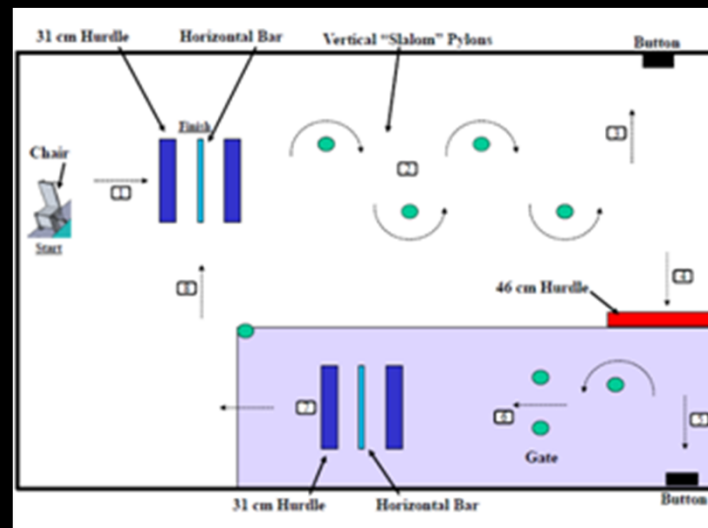
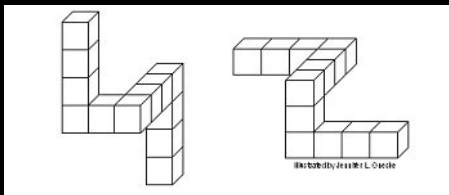
Bo et al. 2011 Neuroimage

Anguera et al. 2010 Journal of Cognitive Neuroscience

Anguera et al. 2011 Journal of Cognitive Neuroscience

Pre & post flight; pre, during & post bedrest tests: behavior

- Spatial cognition, processing speed, bimanual coordination, rod and frame test, functional mobility test, dynamic posturography, click / head tap induced VEMP



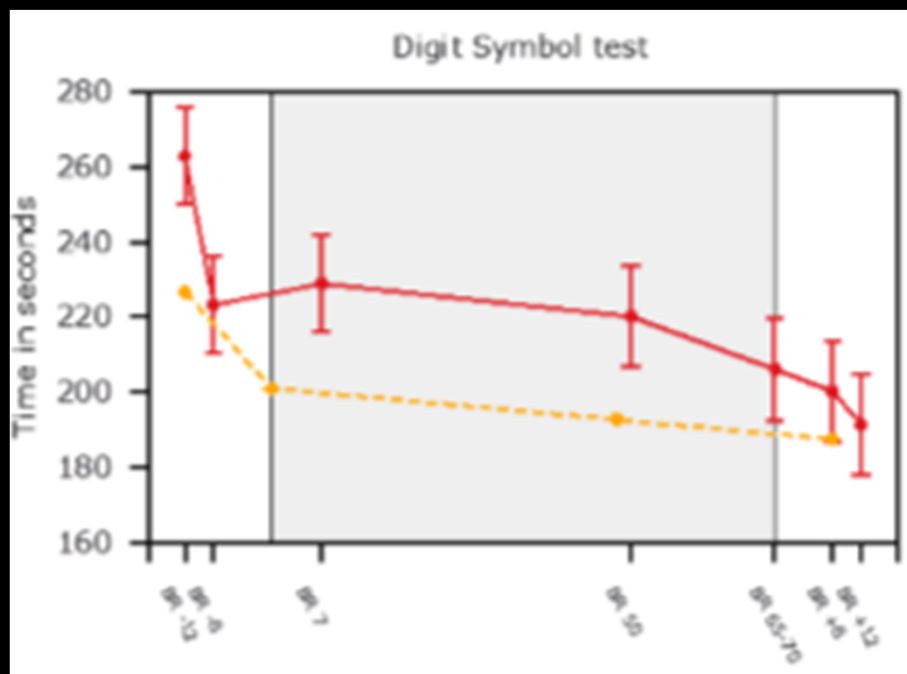
Inflight tests: behavior

- Sensorimotor adaptation
- Spatial cognition
- Cognitive-motor dual tasking

Neuromapping data collection is still IN PROGRESS

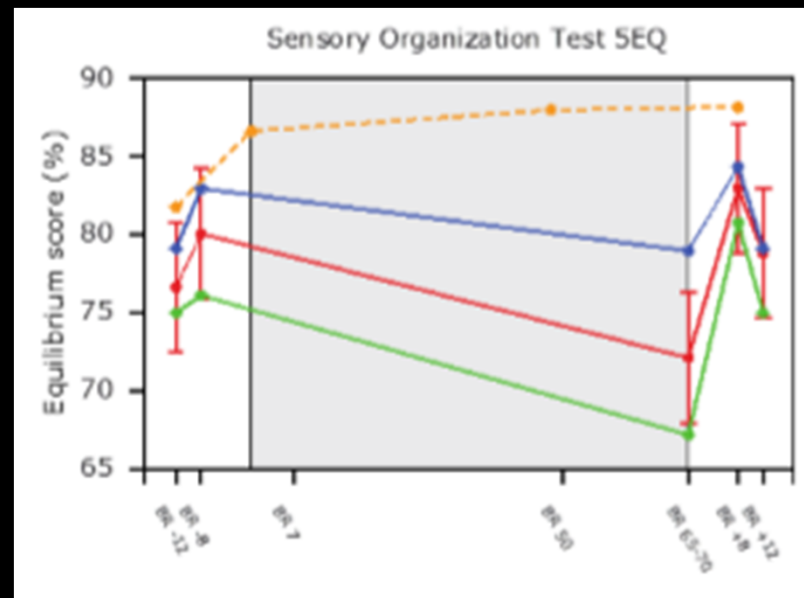
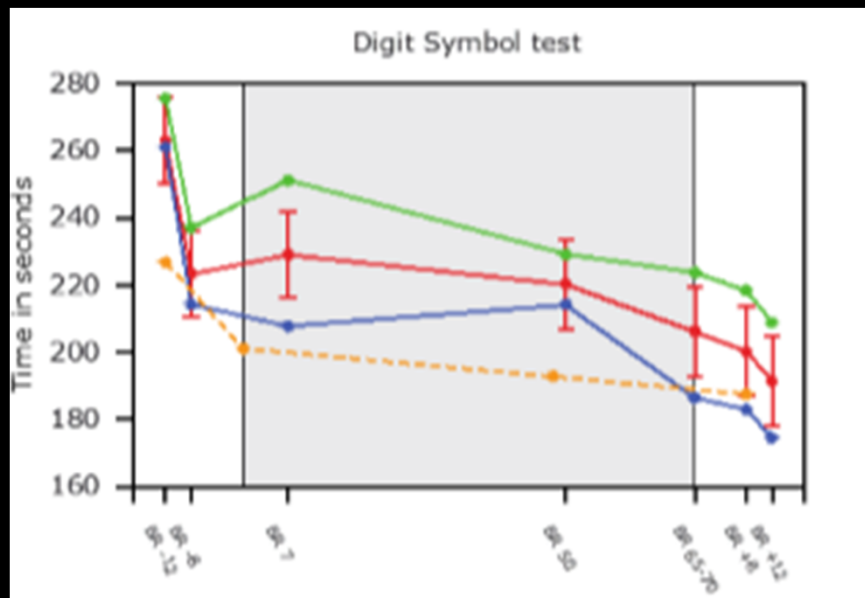
- PRELIMINARY data to be presented today:
 - Balance (sensory organization equilibrium score)
 - Processing speed (digit symbol test performance)
 - Multiple metrics of brain structure
 - Multiple metrics of brain function
 - Single group over time, and subgroups stratified by exercise (Dr. Ploutz-Snyder study)

Bed rest impairs performance



- Long duration head-down 6 degree tilt bed rest (n=10)
- - - Mean performance of a normative control group over a similar time interval (n=5)

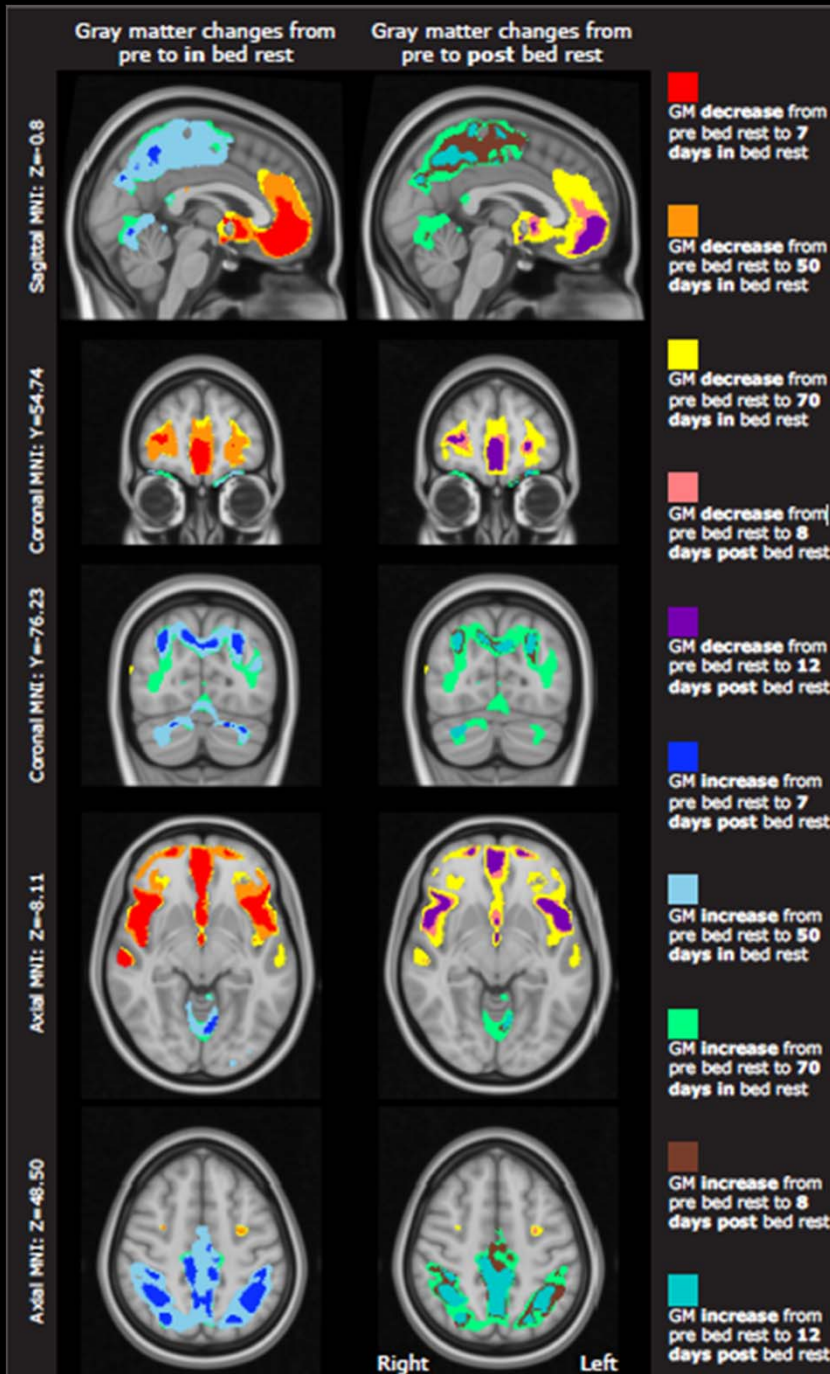
Exercise helps, but it does not eliminate changes



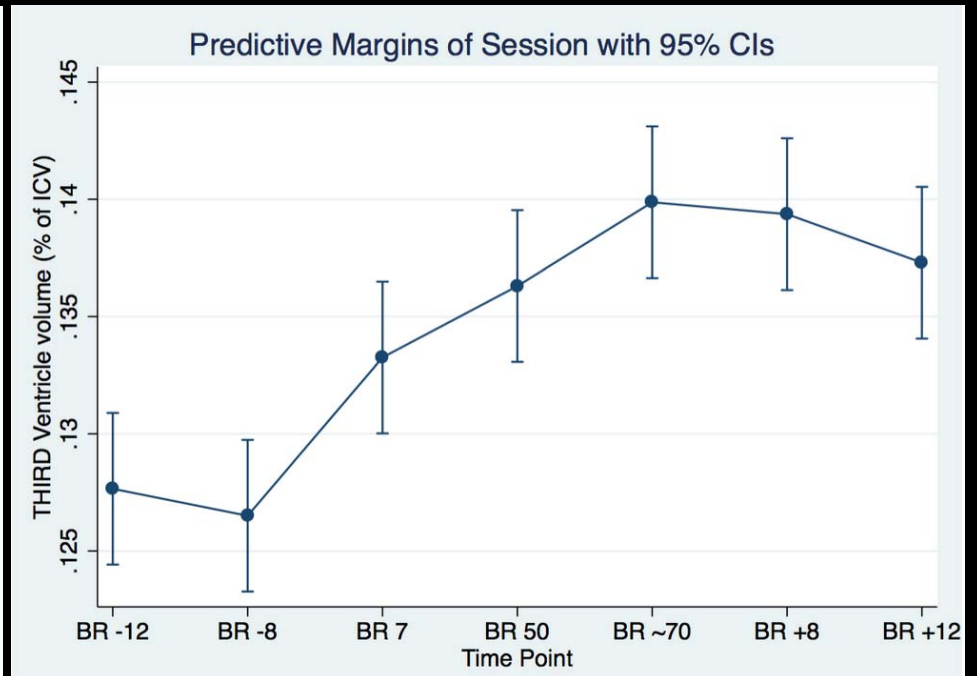
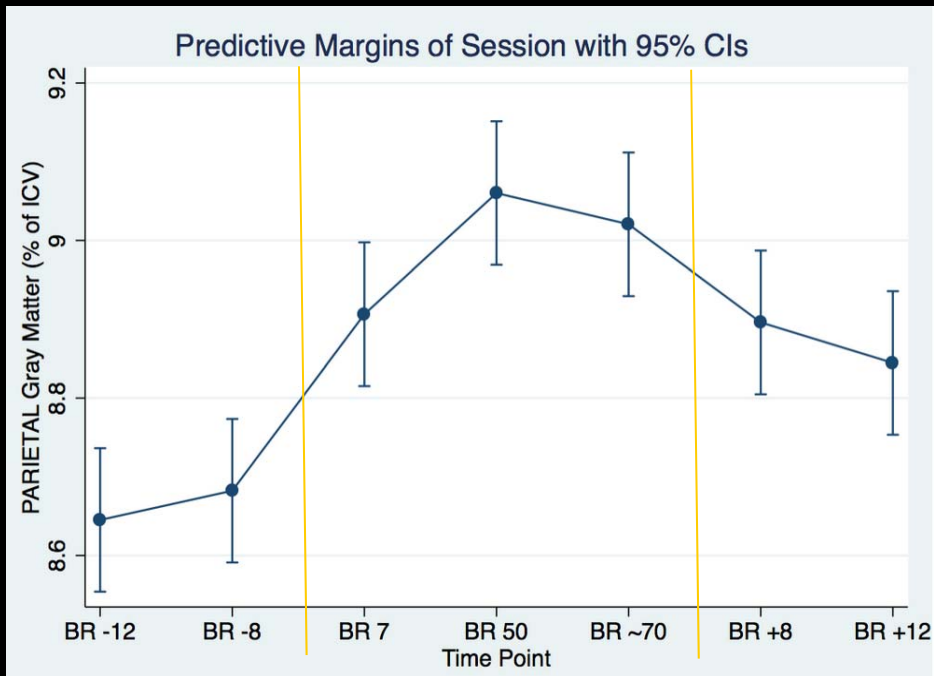
■ Group average (10 subjects) ■ Exercise group (5 subjects) ■ Control group (5 subjects)
- - - Mean performance of a normative control group over a similar time interval (n=5)

Bed rest affects brain structure

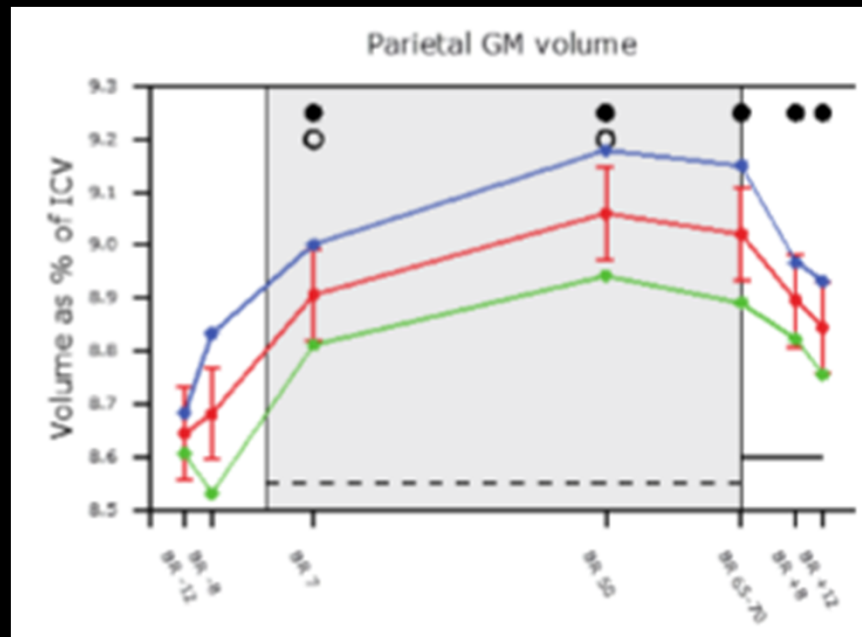
Left column: gray matter volume increases (cool colors) and decreases (warm colors) with long duration head down tilt bed rest (n=10). Right column: recovery of changes post bed rest.



Parietal cortex gray matter & ventricular volume changes

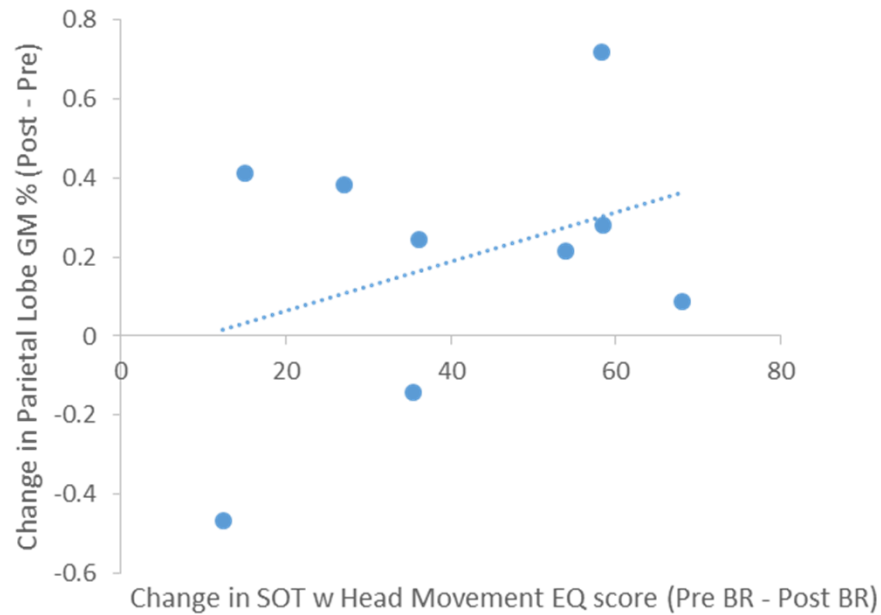


Exercise helps, but it does not eliminate changes



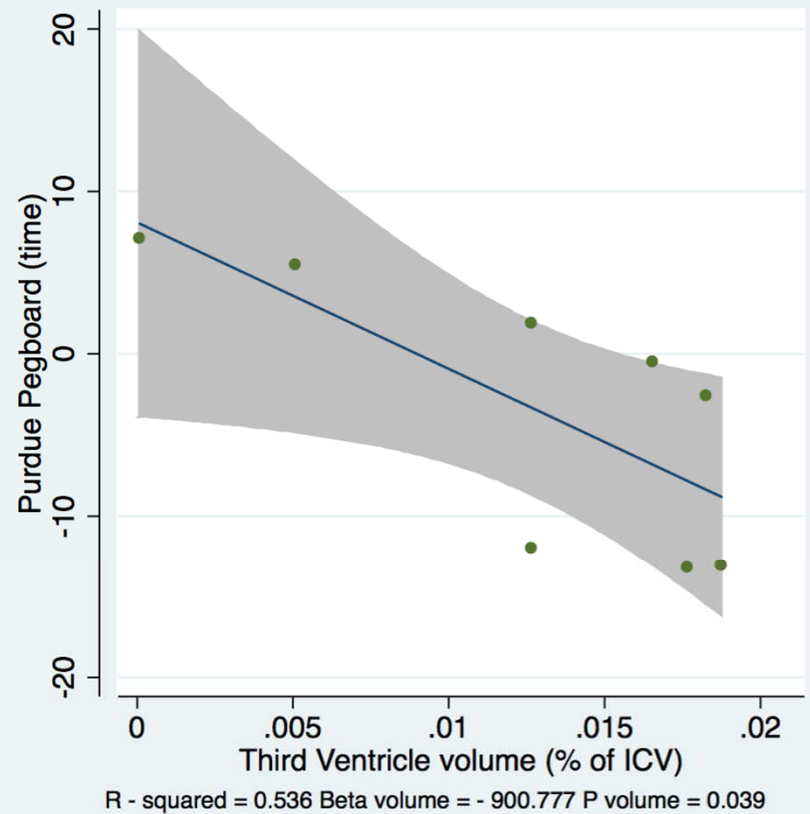
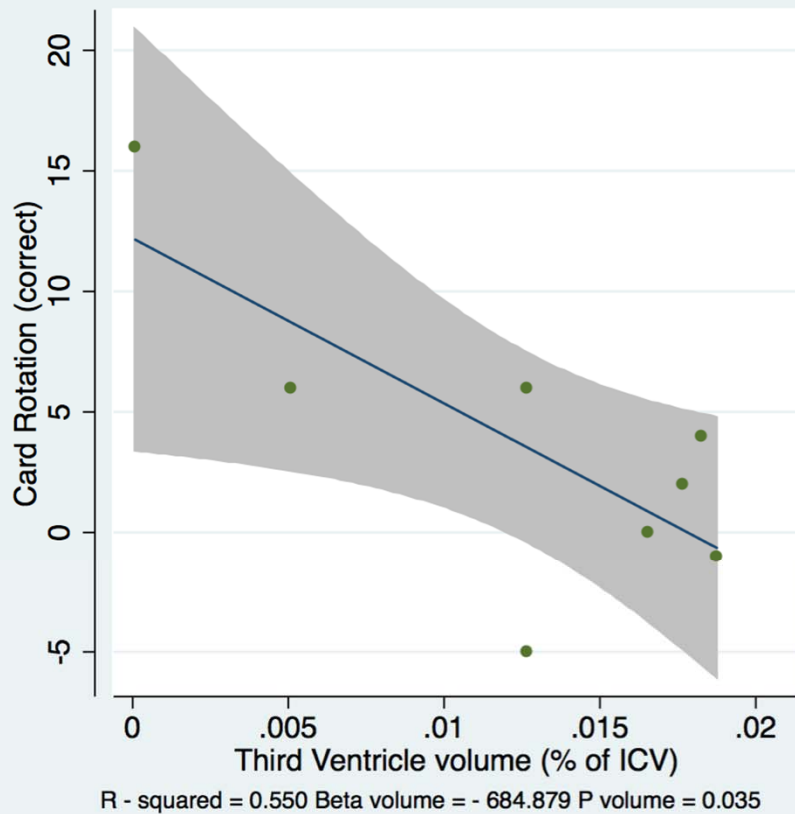
- Group average (10 subjects)
- Exercise group (5 subjects)
- Control group (5 subjects)
- Significantly linear effect of time for the total group
- - - Significantly quadratic effect of time for the total group
- Time point significant different from baseline for the total group
- Time point significant different from previous time point for the total group

Potential links between brain structural & behavioral changes

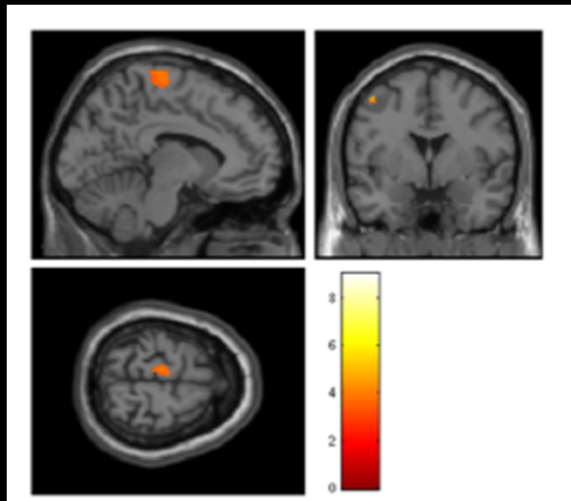


$R=.37$, Greater increases in parietal lobe volume are associated with greater declines in SOT score with bed rest

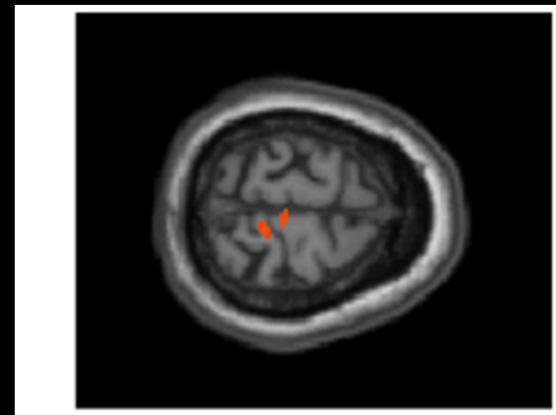
Increases in third ventricular volume are correlated with decreases in card rotation & Purdue Pegboard performance



Brain activity associated with foot movement increases with bed rest



Average activation during foot movement



Brain regions that increase activity with bed rest

Interpretations: preliminary

- Behavior, brain structure, & brain function change with bed rest
- Exercise reduces, but does not eliminate, these changes
- Mechanisms could include fluid shifts, neural plasticity due to altered sensory inputs, compensatory recruitment

Publication Plan

- 1) Effects of bed rest on cognitive & motor behavior, brain structure, & brain function (multiple papers depending upon outcomes)
- 2) Bed rest – exercise interactions, with Dr. Lori Ploutz-Snyder

Acknowledgements



- Ajit Mulavara, Universities Space Research Association
- Jacob Bloomberg, NASA Johnson Space Center
- Lori Ploutz-Snyder, NASA Johnson Space Center
- Scott Wood, Azusa Pacific University
- Igor Kofman, Wyle Science Technology & Engineering Group
- Yiri De Dios, Wyle Science Technology & Engineering Group
- Roy Riascos, UTMB Radiology
- Darcy Szecsy, Bastion Technologies
- Burak Erdeniz, UM
- Vincent Koppelmans, UM
- NASA NNX11AR02G, NASA NCC 9-58, NASA Flight Analogs Project, National Institutes of Health, National Center for Advancing Translational Sciences, 1UL1RR029876-01