

# 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

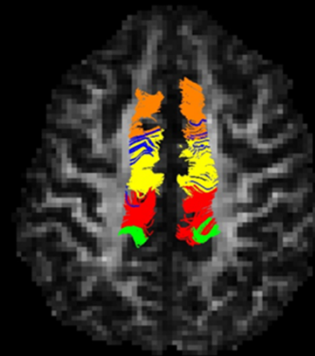
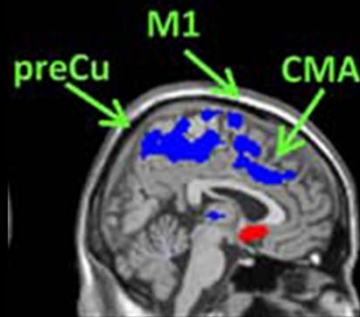
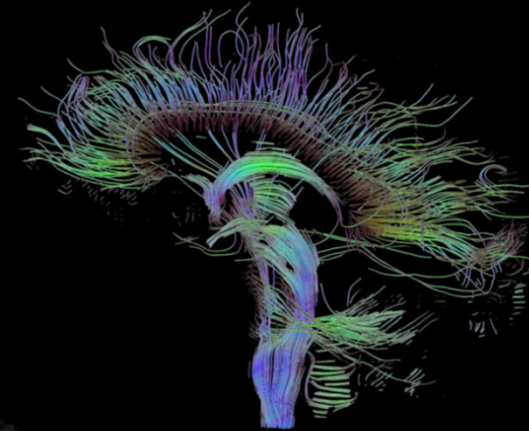
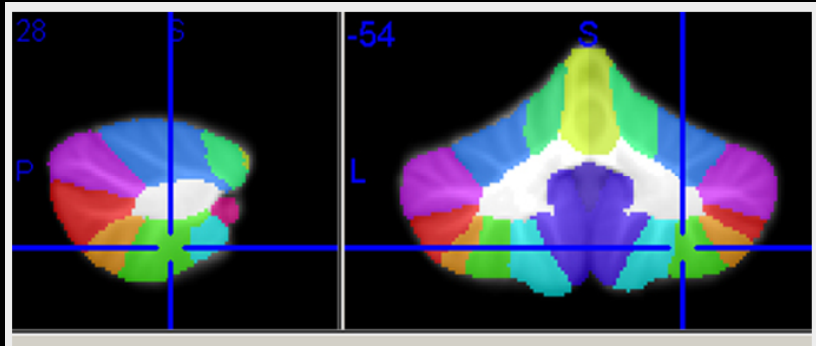
~BR+13



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

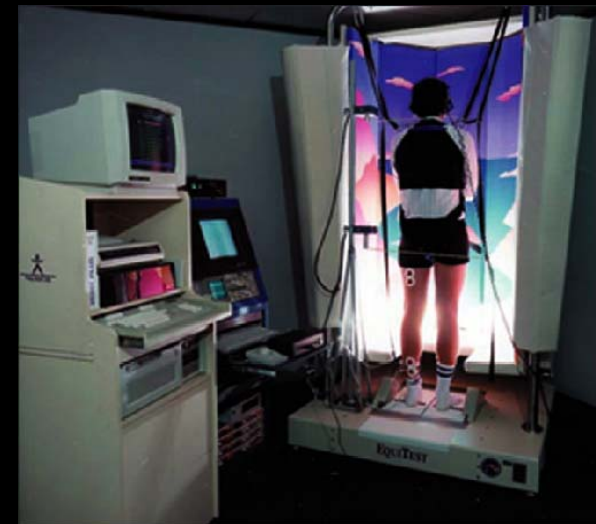
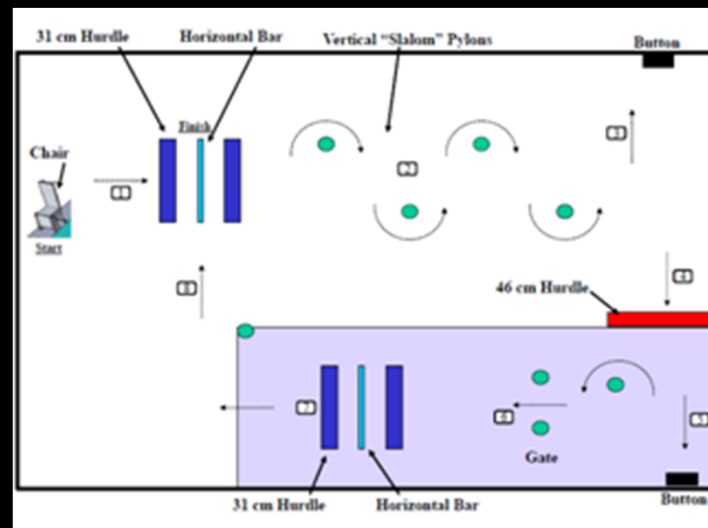
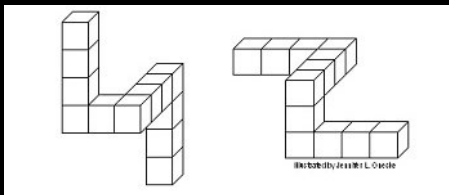
Bo et al. 2011 Neuroimage

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

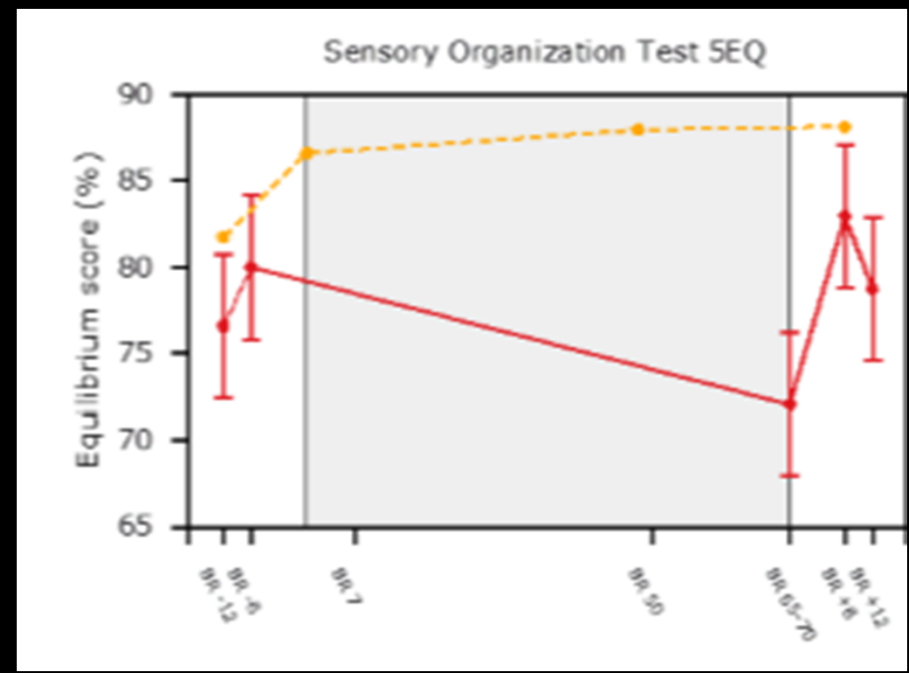
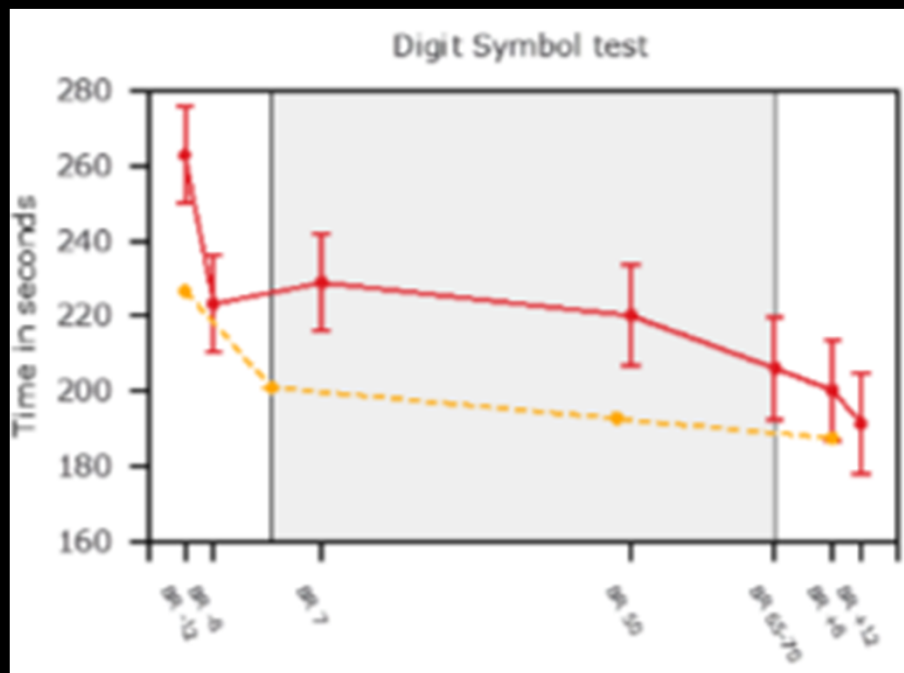
- Sensorimotor adaptation
- Spatial cognition
- Cognitive-motor dual tasking



# Neuromapping data collection is still IN PROGRESS

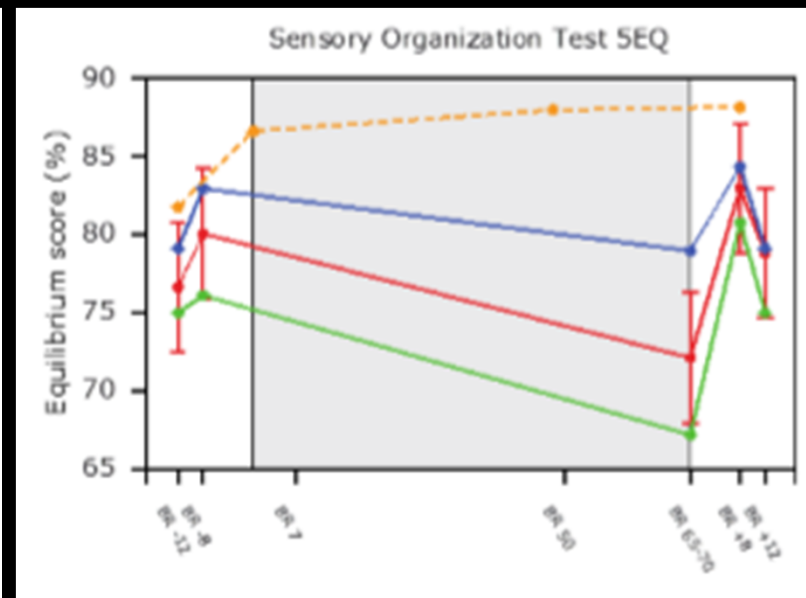
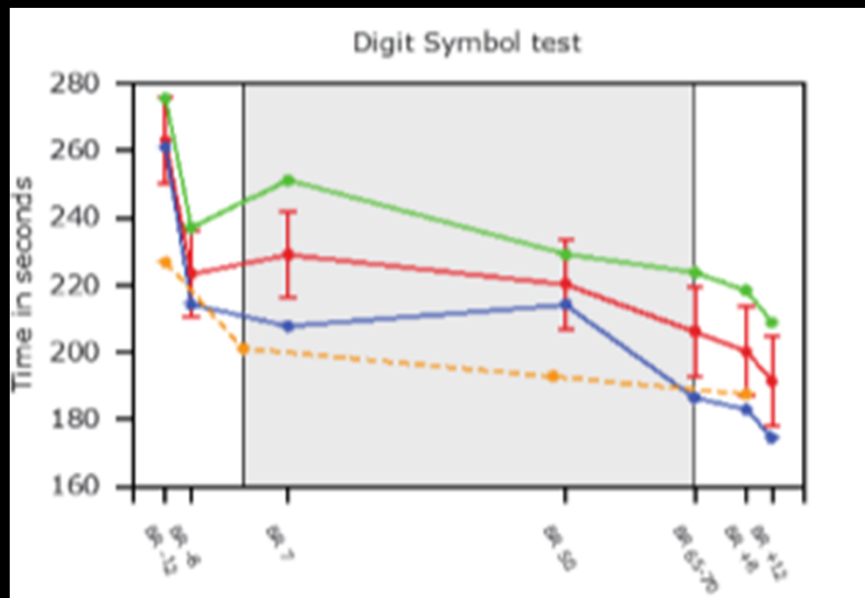
- PRELIMINARY data to be presented today:
  - Balance (sensory organization equilibrium score)
  - Processing speed (digit symbol test performance)
  - Multiple metrics of brain structure
  - Multiple metrics of brain function
  - Single group over time, and subgroups stratified by exercise (Dr. Ploutz-Snyder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

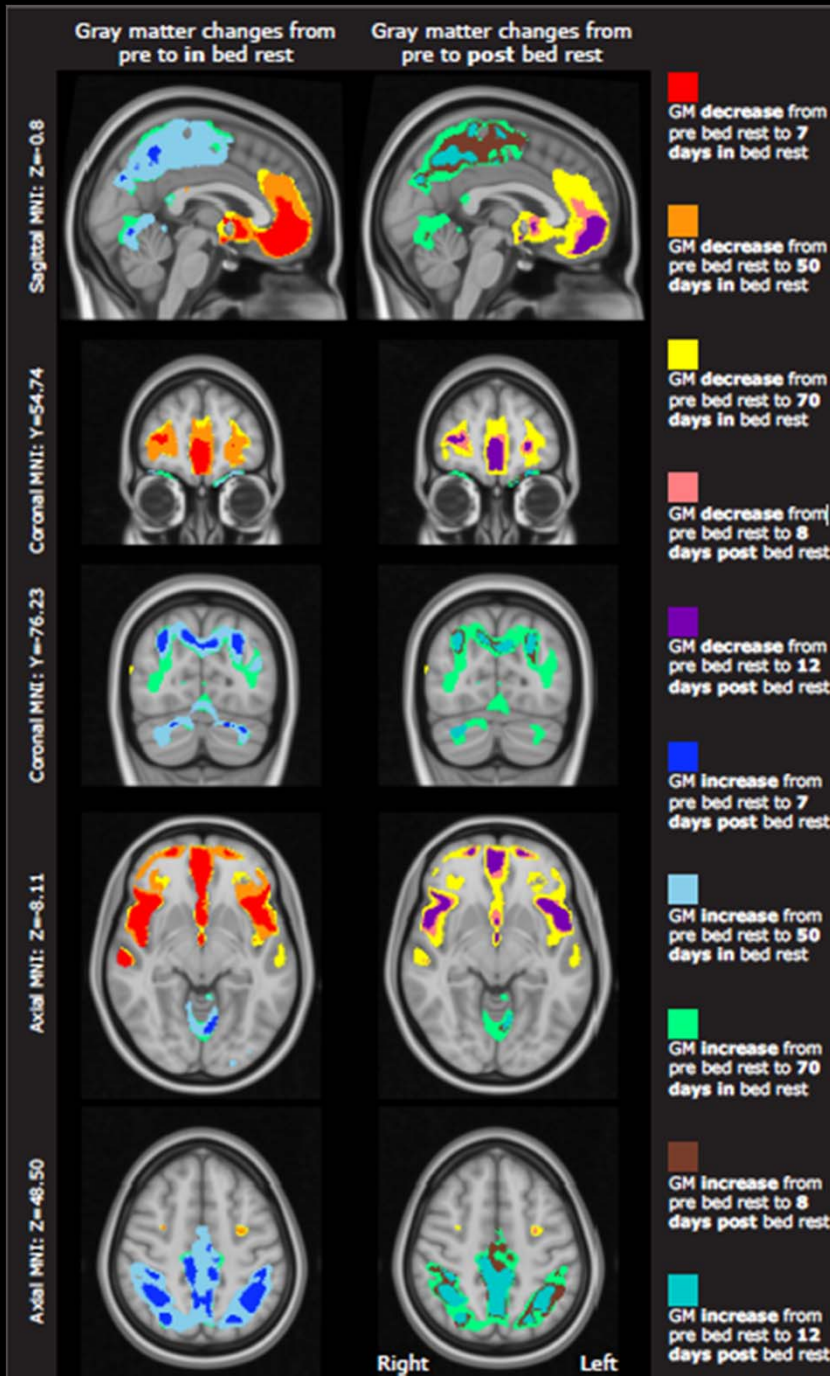
# Exercise helps, but it does not eliminate changes



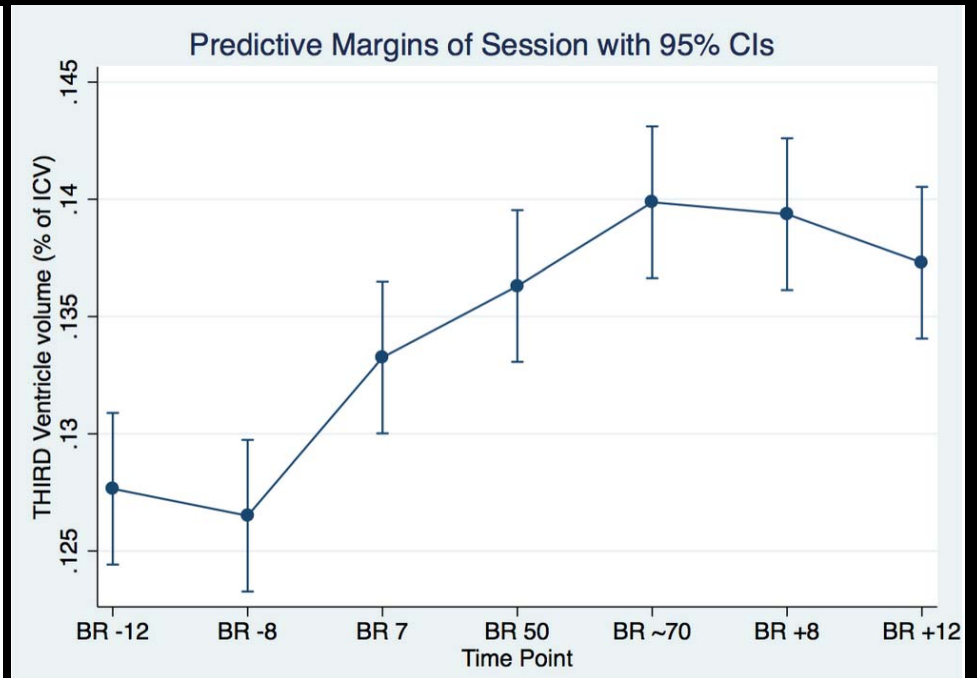
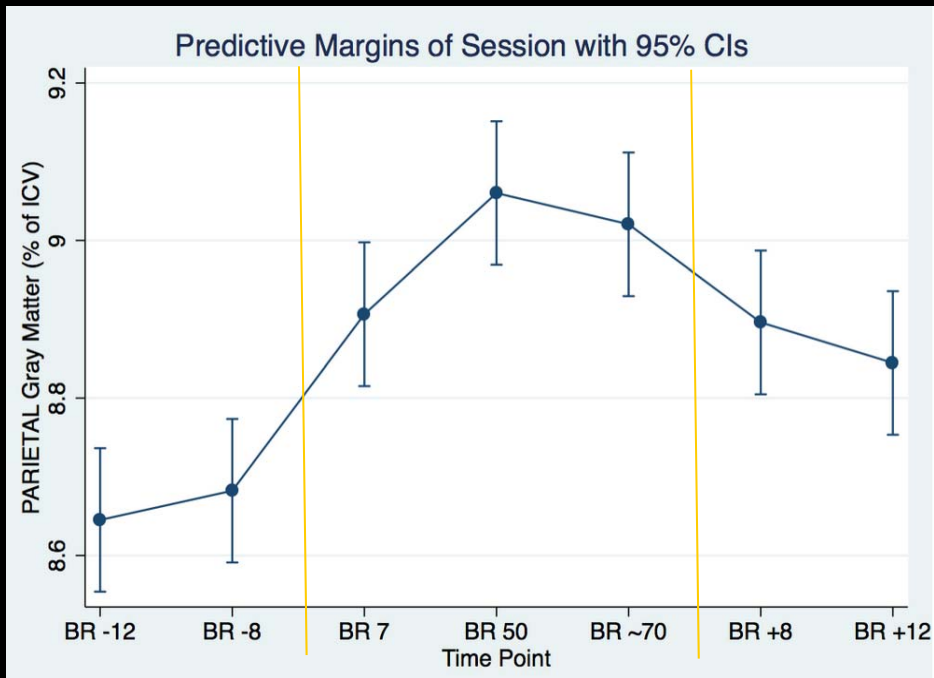
■ Group average (10 subjects) ■ Exercise group (5 subjects) ■ Control group (5 subjects)  
- - - Mean performance of a normative control group over a similar time interval (n=5)

# Bed rest affects brain structure

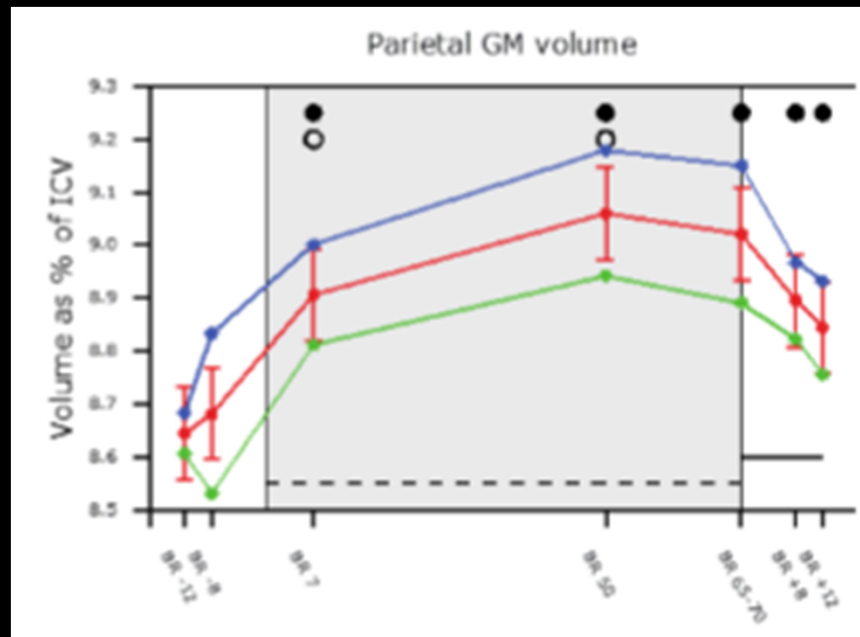
Left column: gray matter volume increases (cool colors) and decreases (warm colors) with long duration head down tilt bed rest (n=10). Right column: recovery of changes post bed rest.



# Parietal cortex gray matter & ventricular volume changes

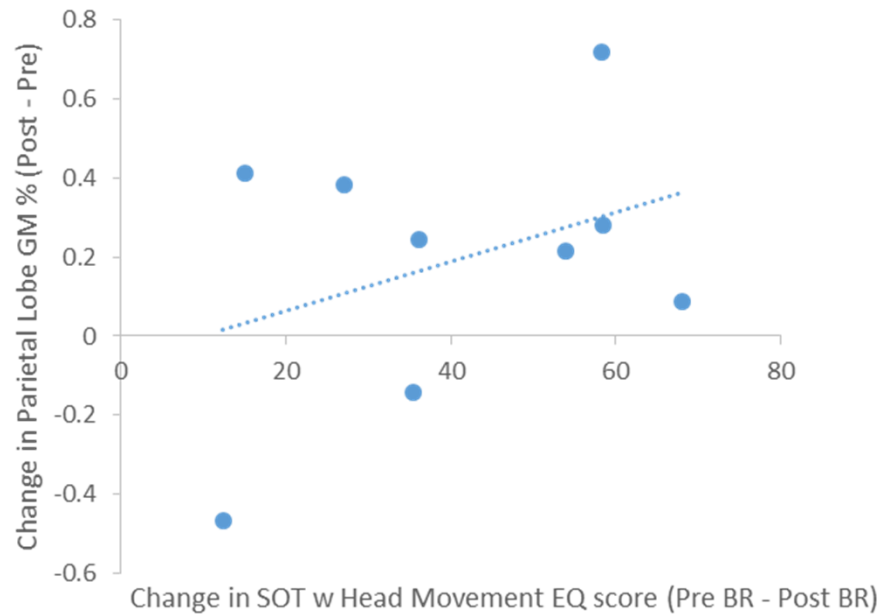


# Exercise helps, but it does not eliminate changes



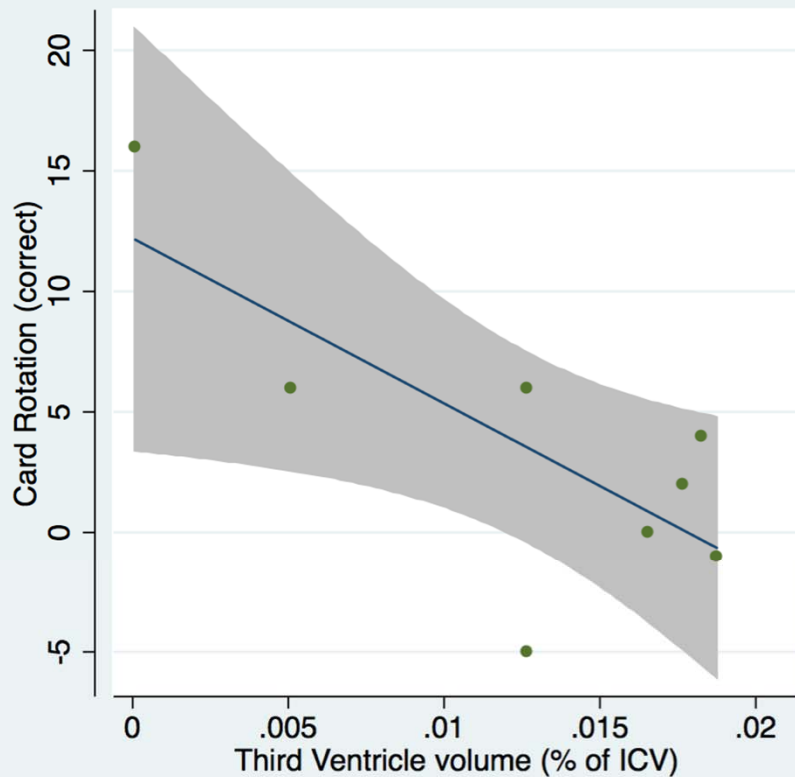
- Group average (10 subjects)
- Exercise group (5 subjects)
- Control group (5 subjects)
- Significantly linear effect of time for the total group
- - - Significantly quadratic effect of time for the total group
- Time point significant different from baseline for the total group
- Time point significant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

# Potential links between brain structural & behavioral changes

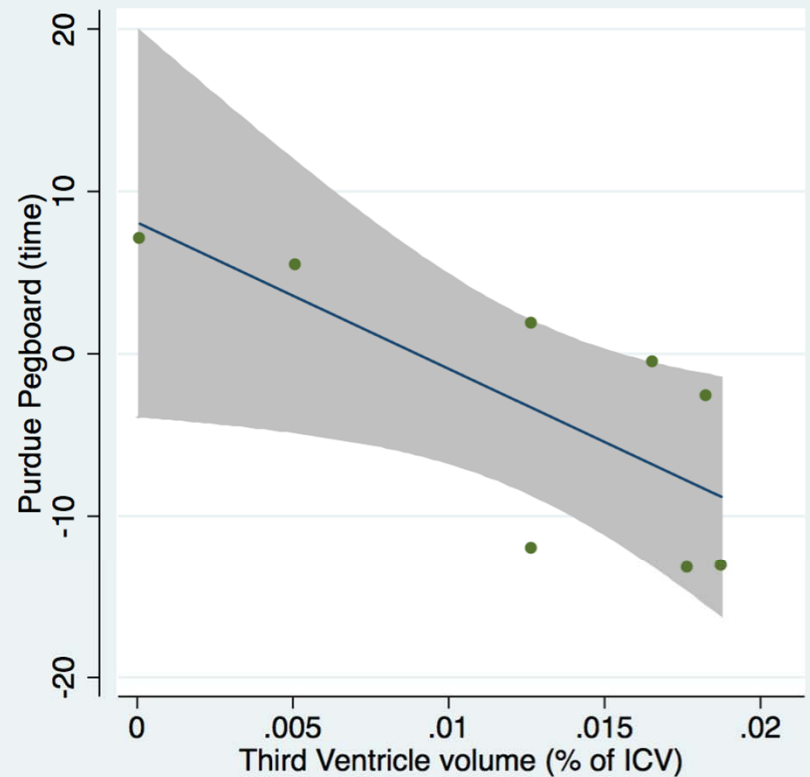


$R=.37$ , Greater increases in parietal lobe volume are associated with greater declines in SOT score with bed rest

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



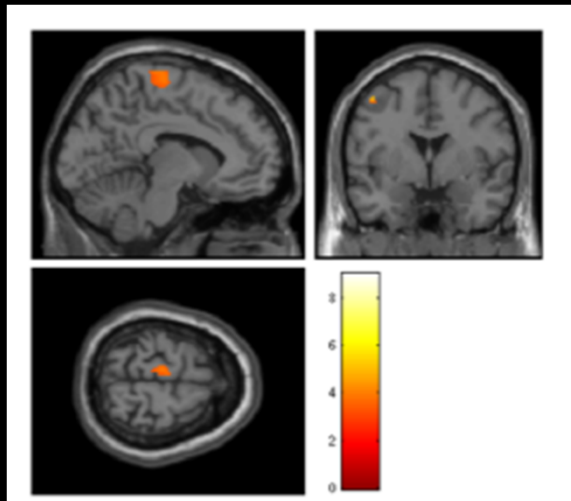
R - squared = 0.550 Beta volume = - 684.879 P volume = 0.035



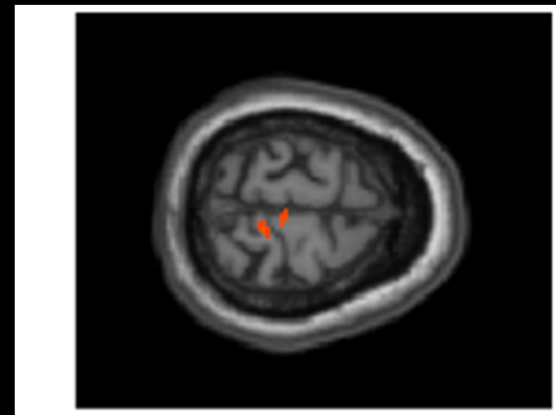
R - squared = 0.536 Beta volume = - 900.777 P volume = 0.039



# 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



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