The Effects of Spaceflight & 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
Specific Aims

- **Aim 1** - Identify changes in brain structure, function, and network integrity as a function of head down tilt bed rest and 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

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

### Testing timeline

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<th>L - 180</th>
<th>L - 60</th>
<th>R+ 2-4</th>
<th>R+30</th>
<th>R+90</th>
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<td>FD30</td>
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Assessments

Structural MRI:
Volumetric gray matter changes
Diffusion weighted images

Functional MRI:
Resting state functional connectivity of cognitive & motor networks
Task based fMRI of motor, cognitive & sensory processing

Additional Behavioral Metrics:
Spatial cognition / working memory
Manual motor control
Vestibular evoked myogenic potentials
Gait & balance (FMT, SOT)
Sensory bias (rod & frame test)
Inflight tests: behavior

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

In these examples, you would tap the Right Trigger button.
Progress Report

- 5, 6-month crew members have completed at least 1 post flight scan, 1, 1 YRM crew member
- CO2 and AG bed rest versions kicking off soon
- Bed rest version of the study is complete, several papers published:
  - Yuan et al. (2016) *Frontiers in Systems Neuroscience*
  - Cassady et al. (2016) *Neuroimage*
  - Four others under review
- Retrospective paper has been published:
Functional mobility declines with bed rest, flight
Balance declines with bed rest, flight
Functional imaging of human vestibular cortex

Noohi et al. under review
Activity increases in somatosensory, visual and frontal cortices in response to vestibular stimulation with bed rest.

Please note that activation results are overlaid onto a standard template brain for presentation.

Peng et al. under review
Greater increases in activation are associated with more mobility slowing

Peng et al. under review

Please note that activation results are overlaid onto a standard template brain for presentation.
Brain responses to vestibular stimulation increase with flight, more so with increasing flight duration (n=6)

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Resting state functional connectivity MRI (fcMRI)
Motor-somatosensory and vestibular-cerebellar connectivity increase with bed rest.

Please note that activation results are overlaid onto a standard template brain for presentation.

Cassady et al. (2016). *Neuroimage*
Larger motor-somatosensory connectivity increases with bed rest were associated with smaller balance decrements.

Cassady et al. (2016). Neuroimage
Intracerebellar connectivity increases with spaceflight (n=6)

Please note that activation results are overlaid onto a standard template brain for presentation.
Bed rest and flight brain structural changes

Koppelmans et al. (in press) npj Microgravity
Larger bed rest increases in GM volume correlate with smaller balance decrements.

Koppelmans et al. (under review a)

Please note that activation results are overlaid onto a standard template brain for presentation.
Bed rest GM changes largely overlap with interstitial fluid shifts measured with dMRI

Koppelmans et al. (under review b)

Please note that activation results are overlaid onto a standard template brain for presentation.
Decreasing free water in somatosensory cortex is associated with smaller balance decrements with bed rest. 

Koppelmans et al. (under review b)

Please note that activation results are overlaid onto a standard template brain for presentation.
• Numerous brain & behavioral changes with bed rest; suggest adaptation, sensory reweighting, and fluid shifts
• Retrospective flight data show some parallels to bed rest, but also large regions of qualitative differences (cerebellum)
• Data collection & analyses for prospective spaceflight study are ongoing
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