



20 years

# Development and validation of sensorimotor assessment tasks using spaceflight analogs



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Investigators' Workshop

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# Background

- A new level of crew autonomy will be required for exploration class missions to self-assess and treat their sensorimotor dysfunction.
- Sensorimotor disorientation is at its highest around periods of gravitational transition (e.g., landing on the lunar/Martian surface).
- There is a need to define sensorimotor assessment tasks that indicate when performance in early extravehicular activities (EVAs) might be impacted or unsafe.

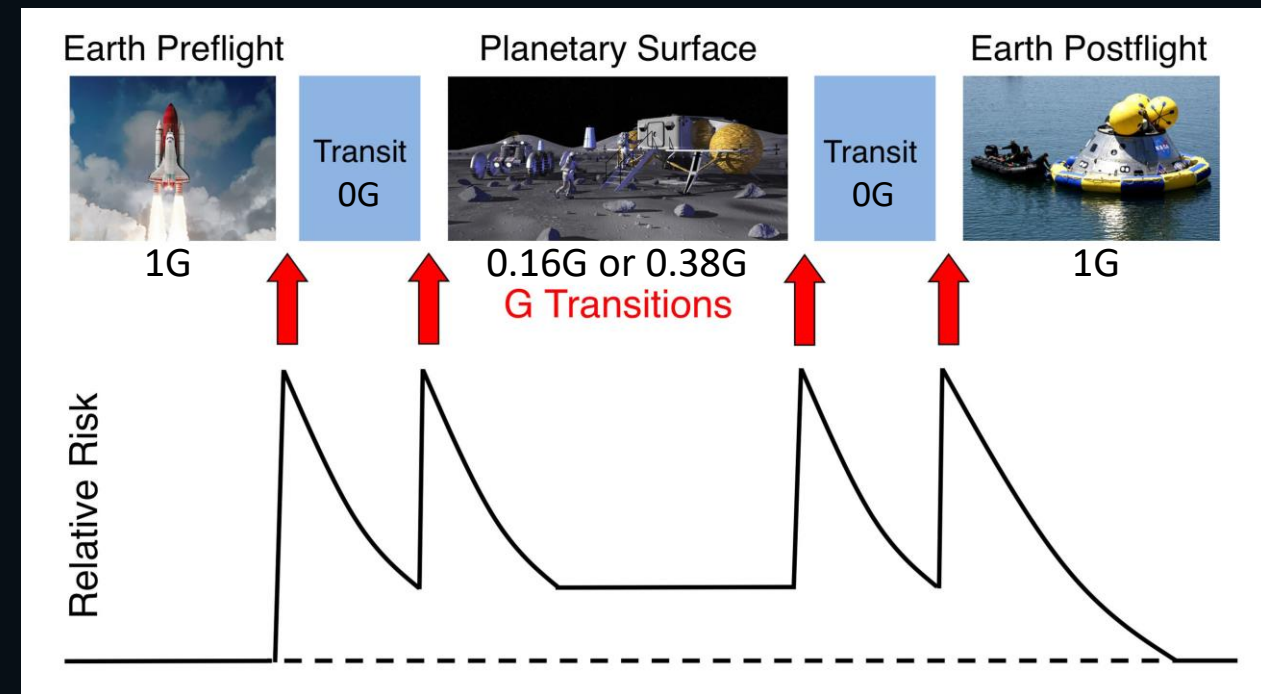


Figure adapted from Clement et al. 2022  
Photos credit NASA

# Background

- The purpose of this study was to develop and validate a set of assessment tasks using two sensorimotor spaceflight analogs:

## Sensorimotor Disorientation Analog (SDA)<sup>1</sup>

### Contains:

Galvanic  
Vestibular  
Stimulation



Weighted  
Suit



### Mimics:

Astronaut  
postflight  
performance at

R+0-24 hours  
(High)

R+24-48 hours  
(Low)

## +3Gx Centrifugation<sup>2,3</sup>

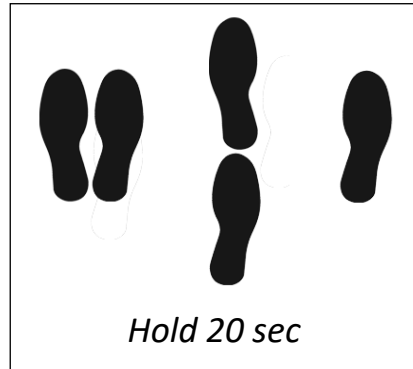


<sup>1</sup>Moudy et al. 2024

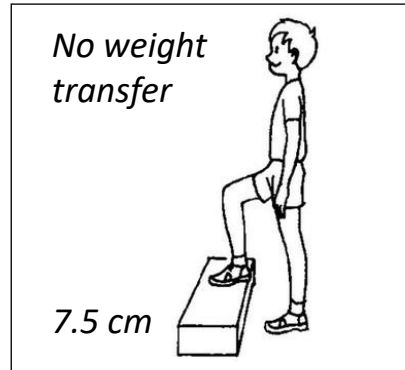
<sup>2</sup>Groen et al. 2008, <sup>3</sup>Nooij et al. 2007

# Sensorimotor Assessment Tasks

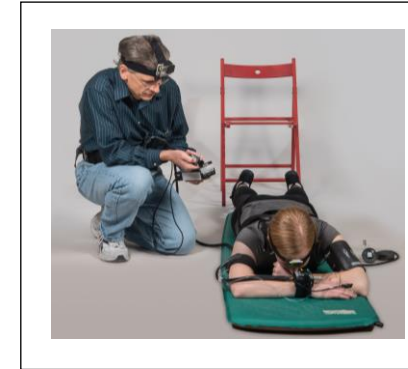
## 1. Postural Challenge



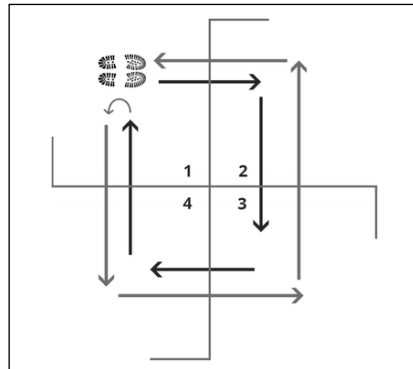
## 2. Step Test



## 3. Fall Recovery



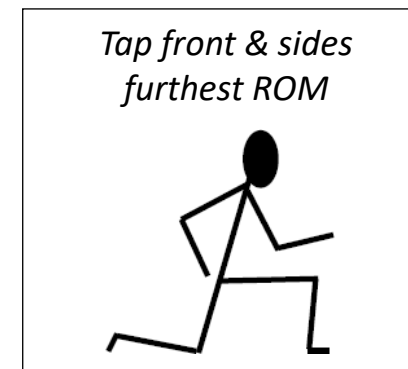
## 4. Four-Square Step Test



## 5. Obstacle Turn



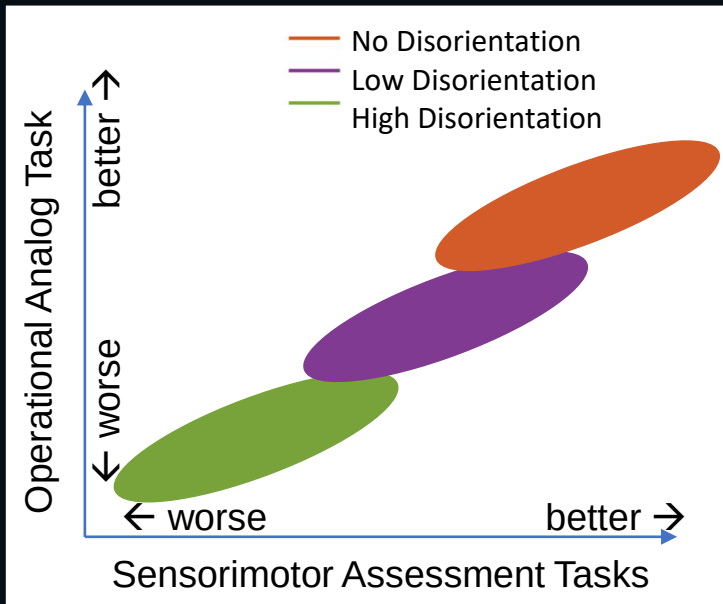
## 6. Kneel-and-Turn



# Validation Through Spaceflight Analogs

Validation and down select of sensorimotor assessment tasks that are:

- 1) the most sensitive to changes in sensorimotor disruption
- 2) correlated to performance in operational analog tasks

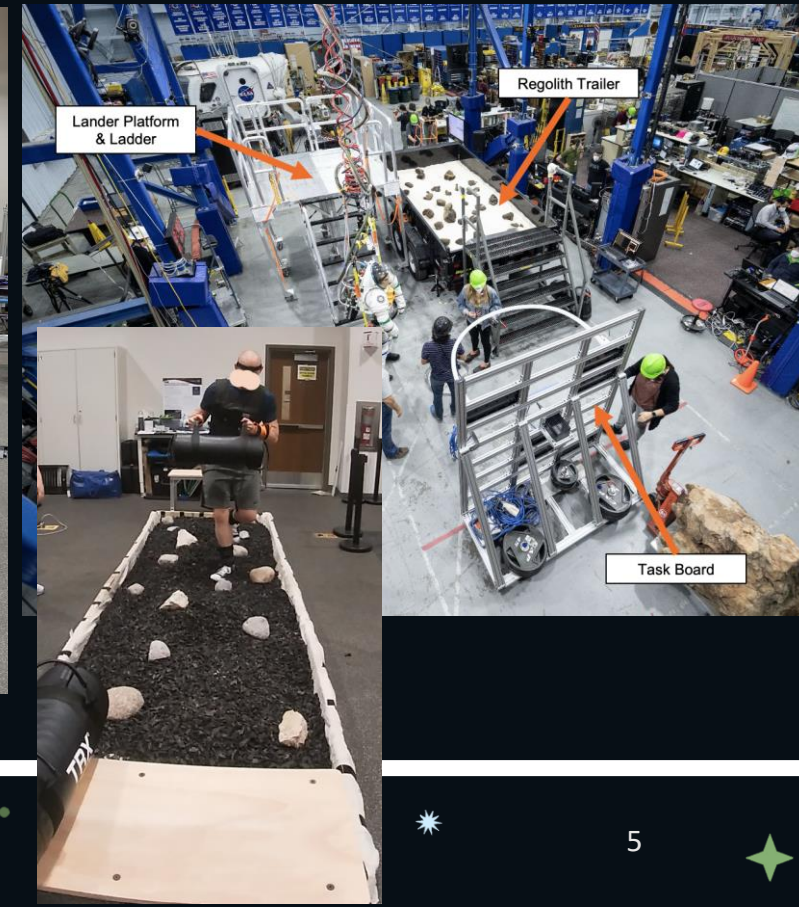


## Operational Analog Tasks

### 1. Top-Hatch Capsule Egress



### 2. Simulated EVA Traversal

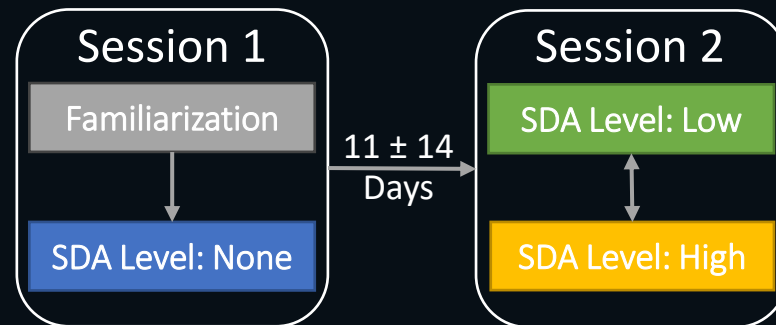


# Methods

## Sensorimotor Disorientation Analog

- 41 subjects participated in two sessions

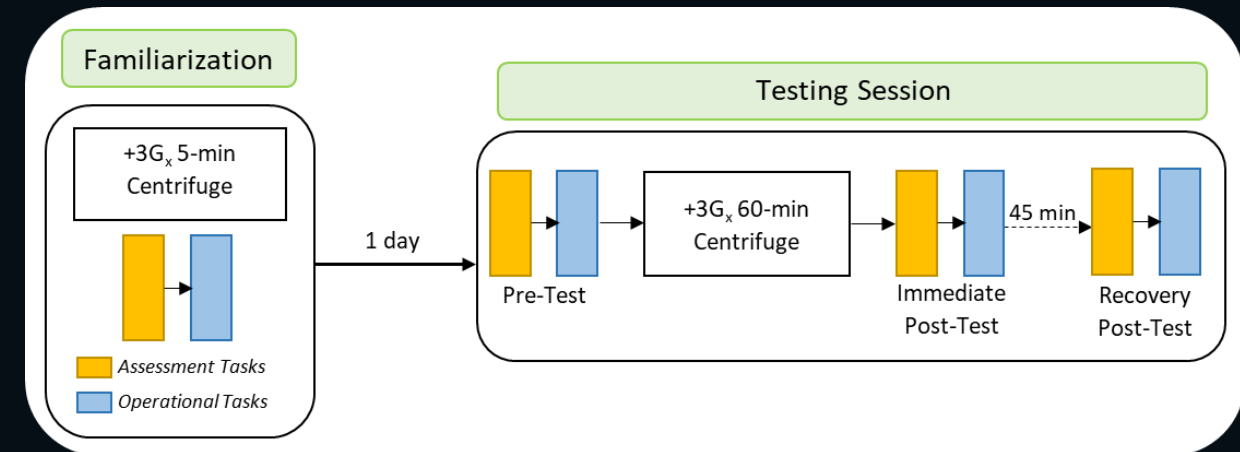
| Age (years) | Height (in) | Weight (lbs) | Women/<br>Men | Low-High /<br>High-Low |
|-------------|-------------|--------------|---------------|------------------------|
| 34.0 ± 7.8  | 68.5 ± 3.4  | 166 ± 29     | 20/21         | 20/21                  |



## +3Gx Centrifugation

- 16 subjects participated in two sessions

| Age (years) | Height (in) | Weight (lbs) | Women/<br>Men |
|-------------|-------------|--------------|---------------|
| 35.0 ± 9.5  | 67.1 ± 2.7  | 172 ± 26     | 6/10          |





# Results

## Task sensitivity to sensorimotor disorientation

**Table 1. Paired *t*-test between SDA levels and pre and post centrifuge**

| Task                  | Sensorimotor Disorientation Analog |              |             | Centrifuge  |
|-----------------------|------------------------------------|--------------|-------------|-------------|
|                       | None vs Low                        | None vs High | Low vs High | Pre vs Post |
| Step Test             | 0.727                              | 0.038        | 0.203       | 0.516       |
| Fall Recovery-Prone   | 0.338                              | <0.001       | 0.003       | <0.001      |
| Fall Recovery-Supine  | 0.094                              | <0.001       | 0.004       | 0.011       |
| Four-Square-Step-Test | 0.213                              | <0.001       | 0.017       | 0.018       |
| Obstacle Turn (OTT)   | 0.005                              | <0.001       | 0.073       | 0.001       |
| Kneel Turn            | 0.507                              | 0.002        | 0.056       | 0.057       |
| Egress Capsule        | 0.520                              | 0.008        | 0.125       | 0.253       |
| EVA Traversal         | 0.004                              | <0.001       | 0.083       | 0.524       |



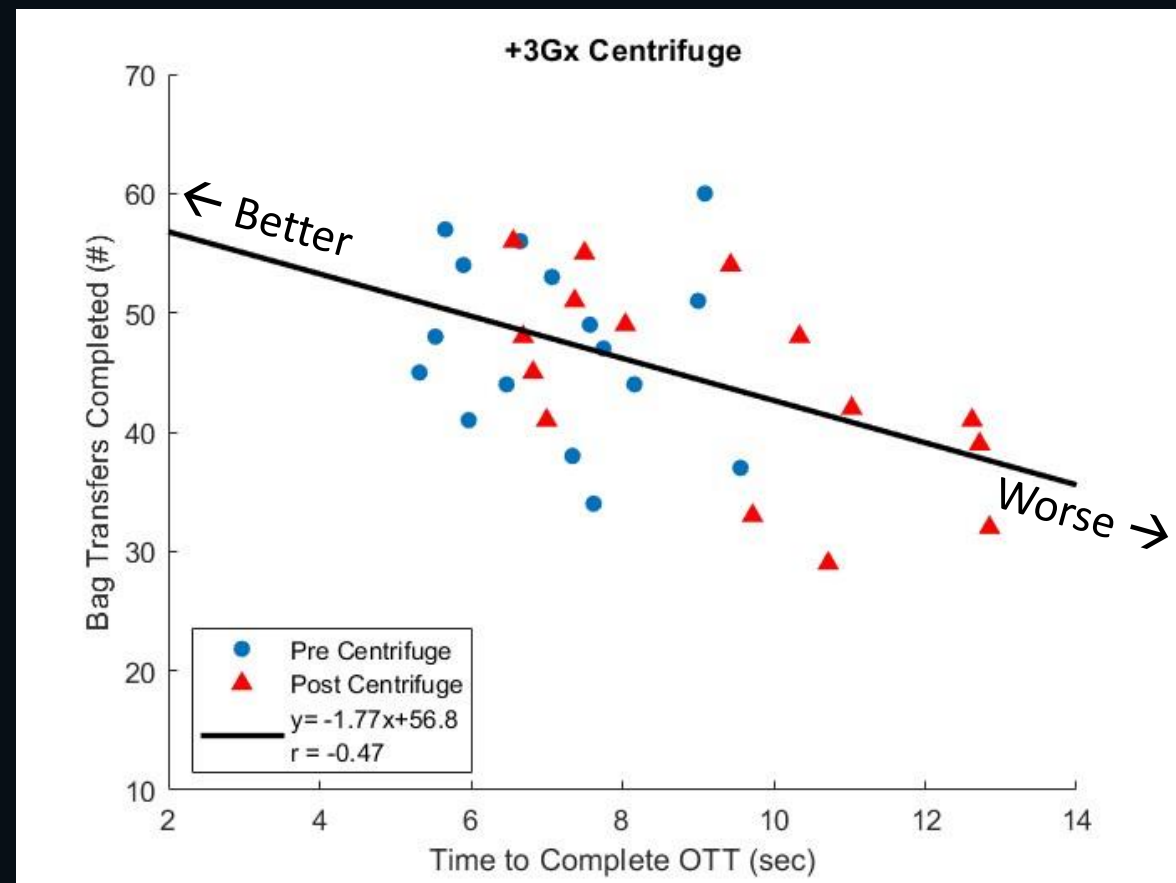
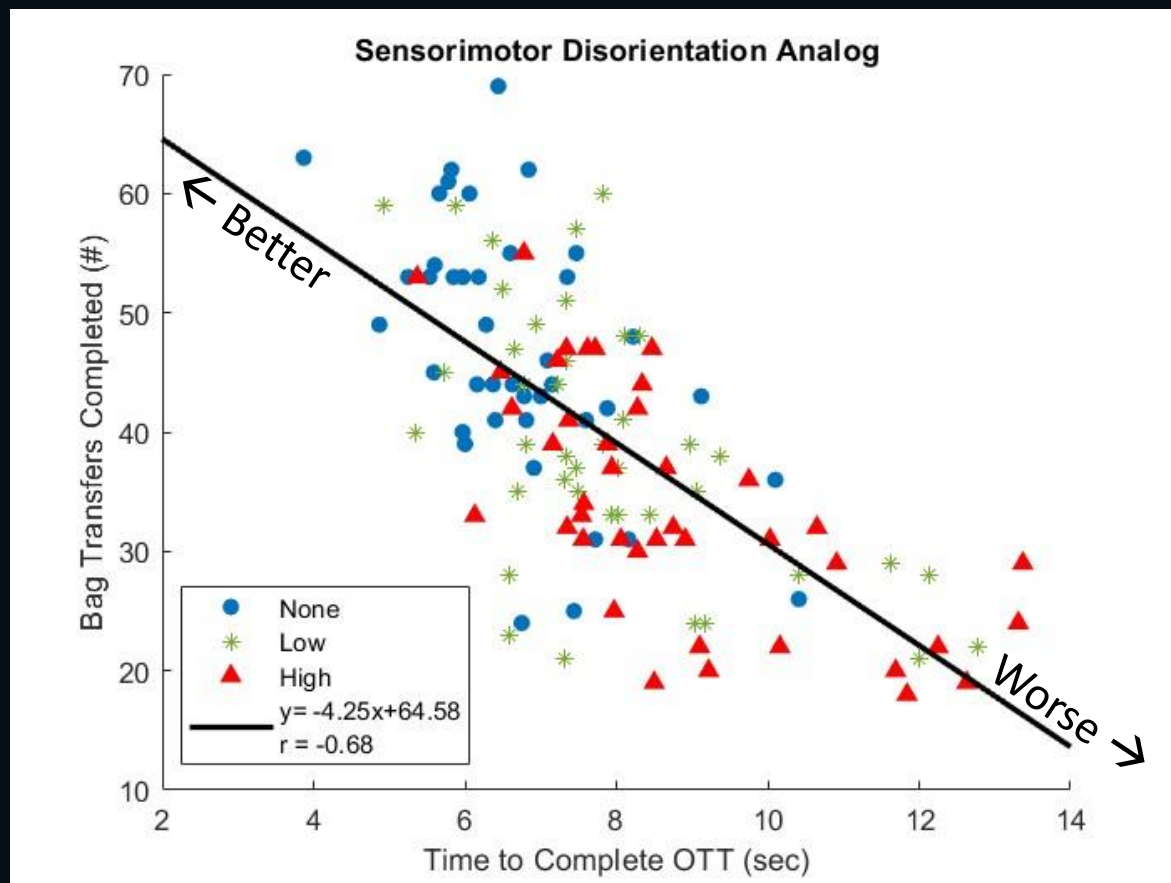
# Results

Correlation to operational analog tasks using all SDA levels and pre and post centrifuge data

| Table 2. SDA correlation <i>r</i> -values |                   |               |
|-------------------------------------------|-------------------|---------------|
| Assessment Tasks                          | Operational Tasks |               |
|                                           | Egress Capsule    | EVA Traversal |
| Step Test                                 | -0.34             | 0.53          |
| Fall Recovery-Prone                       | 0.50              | -0.65         |
| Fall Recovery-Supine                      | 0.45              | -0.63         |
| Four-Square-Step-Test                     | 0.43              | -0.63         |
| Obstacle Turn (OTT)                       | 0.60              | -0.68         |
| Kneel Turn                                | 0.51              | -0.57         |

| Table 3. Centrifuge correlation <i>r</i> -values |                   |               |
|--------------------------------------------------|-------------------|---------------|
| Assessment Tasks                                 | Operational Tasks |               |
|                                                  | Egress Capsule    | EVA Traversal |
| Step Test                                        | -0.23             | 0.32          |
| Fall Recovery-Prone                              | 0.48              | -0.58         |
| Fall Recovery-Supine                             | 0.54              | -0.55         |
| Four-Square-Step-Test                            | 0.67              | -0.59         |
| Obstacle Turn (OTT)                              | 0.40              | -0.47         |
| Kneel Turn                                       | 0.18              | -0.1          |

# Results





# Discussion

- Obstacle Turn Task, Fall Recovery, and Four-Square-Step-Test were the best performing tasks, i.e., sensitive to sensorimotor disorientation
- Given that the operational tasks were conducted after the assessments, the impact of +3Gx on these tasks was limited due to the quicker than expected recovery
- Previously flown crewmember with extensive EVA analog experience stated the Obstacle Turn and Fall Recovery tasks represented body mechanics required during EVAs
- These studies helped down select assessment tasks and map performance to operational analogs where future studies can help define performance limits in partial gravity (e.g., parabolic flight, Artemis missions)

# Thank you!



KBR AEPL for support in conducting the centrifuge runs

Neuroscience Lab for support in data collection

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Countermeasures Element

