



# Effects of Long-Duration Microgravity on Fine Motor Skills: ISS One-Year Mission



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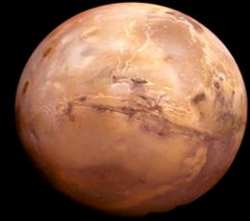
**Human Research Program  
Human Factors and Behavioral  
Performance**

January 23, 2017





# Background



- Fine motor skills will be critical in future long-duration missions, particularly those skills needed to interact with advanced technologies in next-generation vehicles, spacesuits, and habitats.
- Studies to date on the effects of microgravity and gravitational transitions on fine motor performance have not yielded conclusive results.
  - Datasets are incomplete – timeline gaps in the microgravity data sessions
  - Studies have not focused on the fine motor actions that are likely to be required for interacting with software displays and controls (pointing, clicking, dragging, multi-touch/pinching). The majority of studies have used a joystick or arm reaching task.
  - Touchscreen tablets are already in use on ISS, and at least one commercial partner is already planning a cockpit with touchscreens as the primary means of input.

**We must ensure that crewmembers are ready to perform with computer-based devices after a long-duration voyage and transition to surface operations.**



# Objectives



- Objective 1: Determine the effects of long-duration microgravity on fine motor performance.
  - How does fine motor performance in microgravity vary over the duration of year-long and 6-month space missions?
  - How does motor performance on orbit compare to that of a matched ground subject?
  
- Objective 2: Determine the effects of different gravitational transitions on fine motor performance.
  - How does performance vary before and after gravitational transitions, including the periods of early flight adaptation, and early, near-immediate postflight periods?



# Subjects



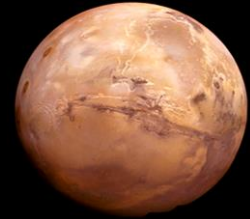
## Data Collection

- |   |                             |
|---|-----------------------------|
| • 2 One-year flight subjects (1 U.S. and 1 Russian)               | 2 complete                  |
| • 1 One-year ground subject matched to a flight subject           | 1 complete                  |
| • 6 Standard duration (6-mth) flight subjects with ground matches | 4 complete<br>2 in progress |

NOTE: Ground subjects are “astronaut-like” and matched to flight subjects by age and gender. They follow the same schedule as their flight counterparts, with a lag of several weeks.



# Fine Motor Skills Hardware and Software



- Data collection is accomplished using a custom Fine Motor Skills Test Battery Application on an Apple iPad3®.
  - Native iPad application installed on iPads sent to the ISS.
  - Application presents instructions, tasks, and questionnaires.
  - Data collected includes response times, errors, and X-Y coordinates.
- A custom iPad handhold is used to promote stable, standard positioning of the iPad for all sessions across subjects.
- Tasks are completed using a finger and a stylus on the touchscreen (according to onscreen instructions).
- Data are received via weekly downlinks.



Custom handhold used during test sessions



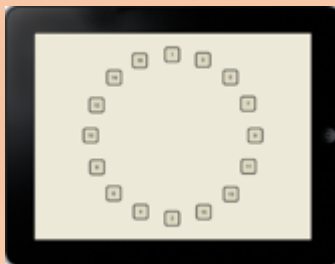
Custom handhold and stylus in use during demonstration



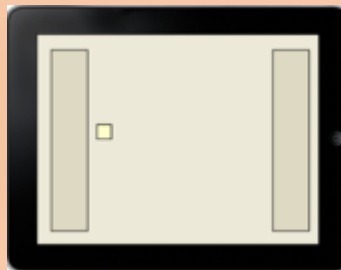
# Fine Motor Skills Sessions



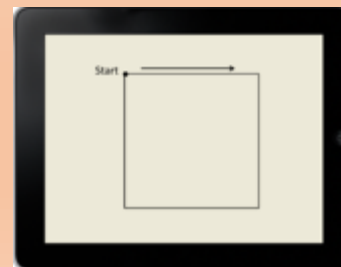
- Login and introductory questionnaire (4 questions)
- Test battery of 4 fine motor tasks (with variations of size and orientation)
- Instructions indicate whether finger or stylus should be used for each block of trials
- Tasks appear in a different order for each session.
- Software measures response time and accuracy.
- Data automatically sent to the server.



Multidirectional  
Pointing



Unidirectional  
Dragging



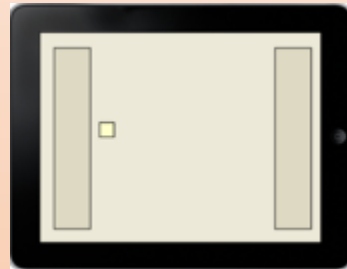
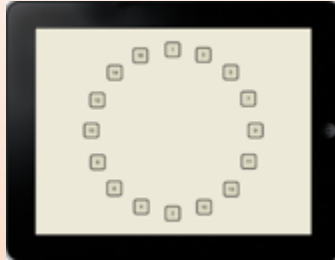
Shape Tracing



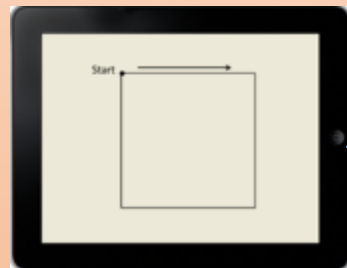
Pinch-Rotate



# Rationale for Task Selection



Pointing and Dragging tasks based on ISO 9241-9 for the evaluation of cursor control devices. Includes the key interface operations of pointing, clicking, and dragging.



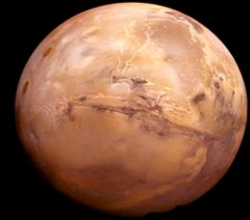
Shape Tracing is a common task for the measurement of fine motor skills, typically done with pen and paper.



Multi-touch pinch and rotate operations are common tasks on modern touch interfaces.



# Questionnaires in the Software



## Pre-session

Welcome, Training!

If you aren't Training, tap here to go back:

**Back**

\* Required

\* 1. Right now, I feel alert.

1 - Disagree      2      3      4      5 - Agree

\* 2. Which of these activities did you perform during the last hour? Check all that apply:

Sleep

Exercise

Sedentary work

Physical work

Other

\* 3. Please describe the task location and your posture/use of restraints for this test session. If same as last session, enter "Same".

4. Is there any additional information you would like to provide that might affect this task session?

**Submit Survey**

## Post-session

You have completed this session!

Is there anything you would like to tell us about this session (interruptions, problems, motivation)?

**Submit**



## Fun, post-session motivator





# Data Collection Schedule and Duration



## • Schedule

- Familiarization session (~L-90)
- Preflight (4 times within L-90 to L-60)
- Inflight
  - As soon as possible, but no later than FD 2, 5
  - Every 5 days for the first 3 months
  - Every 14 days for the remainder of the flight
  - Last session within R-7
- Early Postflight
  - R+0 (2), R+1, +3
- Late Postflight
  - R+5, R+15, R+30

## • Duration

- ~15 min per session
- ~5 min per session for early postflight sessions (R+0, R+1, R+3).
  - Shorter test battery developed to accommodate postflight crew time constraints



# Quality of the 1YM Dataset



- 1YM Crewmember #1

Number of completed or missed sessions and comments about deviations from protocol

- 1YM Crewmember #2

Number of completed or missed sessions and comments about deviations from protocol

- Ground match

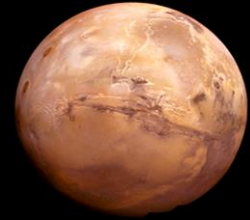
Number of completed or missed sessions and comments about deviations from protocol

# Redacted

Statement about data challenges



# About Results



- Standard duration subjects are still in progress, thus only descriptive results will be presented at this time
- Due to time constraints, only the Small Pointing and Circle Tracing task results will be presented
- Response Times for both tasks
  - RT change from baseline (median)
- Errors for Pointing Task
  - Number of extraneous (off-target) touches/Total number of touches
- Errors for Tracing Task
  - Mean deviation from target (Euclidean distance in pixels)

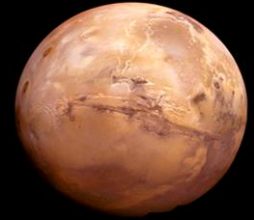
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Example data for Pointing and Tracing tasks



# Small Pointing Task for Flight Crew #1



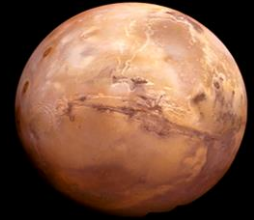
Graph showing Response Times

Graph showing Errors

Redacted



# Small Pointing Task for Flight Crew #2



Graph showing Response Times

Graph showing Errors

Redacted



# Circle Tracing Task for Flight Crew #1



Graph showing Response Times

Graph showing Errors

Redacted



# Circle Tracing Task for Flight Crew #2



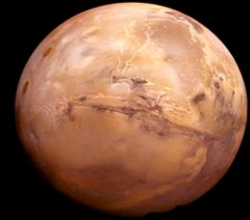
Graph showing Response Times

Graph showing Errors

Redacted



# High-level Observations



Text describing high-level observations about the data

Redacted





# Tentative Conclusions



- Does the transition from pre-flight to early microgravity adaptation impact fine motor performance?

Responses to question

- Does fine motor performance change over the course of a long-duration mission?

Responses to question

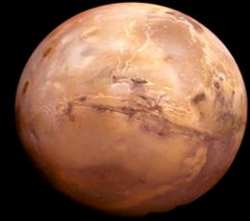
- Does the transition from long-duration flight to early postflight (1-g) impact fine motor performance?

Responses to question

Redacted



# Fine Motor Skills Investigation on the ISS 1-YR Mission



For a NASA video detailing this investigation:

<http://youtu.be/-ZAcBOf6nnE>



# Questions?

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