

COE CST Eleventh Annual Technical Meeting

Human Input Systems for Commercial Space Transportation

**Thomas C Eskridge PI
Dan Kirk Co-PI, Don Platt Co-PI
Troy R Weekes, Researcher
Kazuhiko Momose (PhD student)
Andrew Biron (PhD Student)**



Center of Excellence for
Commercial Space Transportation



Agenda

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- Task Description
- Schedule
- Goals
- Results
- Conclusions and Future Work

Team Members



Thomas C
Eskridge
PI



Daniel
Kirk
Co-PI



Don
Platt
Co-PI



Troy
Weekes
Researcher



Kazuhiko
Momose
HCD PhD
Student



Andrew
Biron
HCD PhD
Student

Task Description

- This project will develop guides for the CST industry in the area of definition and engineering of CST control input devices and systems usable in variable gravity with or without spacesuit.

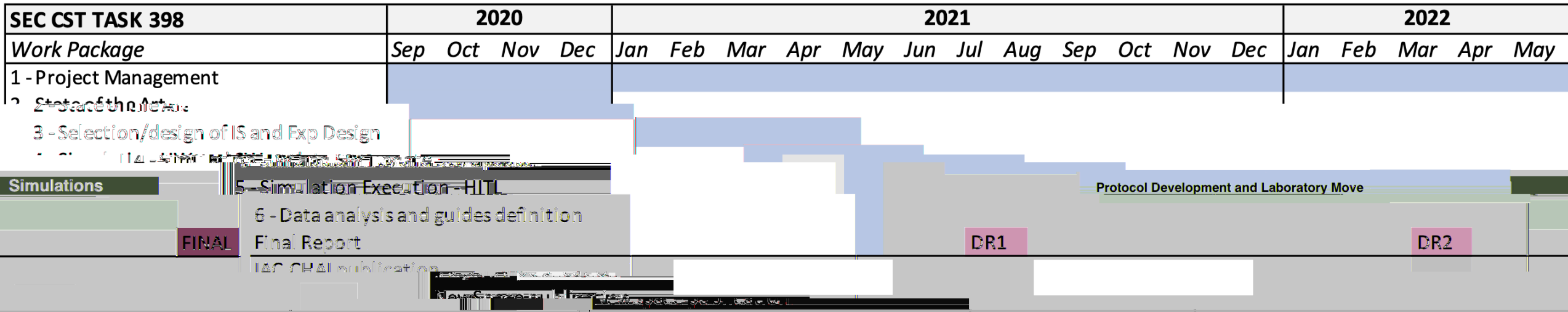


Control in Variable Gravity

- Control of vehicles require
 - good visual acuity,
 - eye-hand coordination,
 - spatial and geographic orientation perception, and
 - cognitive function.
- Space flight research has demonstrated the effects of variable gravity on each of these requirements

Bloomberg JJ, Reschke MF, Clément GR, Mulavara AP, Taylor LC. NASA evidence report: Risk of impaired control of spacecraft/associated systems and decreased mobility due to vestibular/sensorimotor alterations associated with space flight. 2016. [September 12, 2016]. <https://humanresearchroadmap.nasa.gov/Evidence/reports/SM.pdf>. [Reference list]

Schedule



Goals

1. **Identify the best human input physio-cognitive control logic and mechanisms for human operators in variable gravity environment**
2. Identify satisfactory multimodal feedback for confirmation of actions in hyperbaric, variable gravity environment.
3. A homing function for input devices can be misinterpreted when using spacesuit and/or operating the vehicle in variable gravity environment. Determine whether an input device should have a homing function and, if so, how it should be communicated to the user.
4. Identify the personal physical and cognitive ergonomic features of vehicle occupants that should be driving the cockpit cognitive and physical ergonomics adaptation.
5. Determine fundamental rules of how to secure optimal performance of the mission and safety of astronauts in interactions with adaptive automation

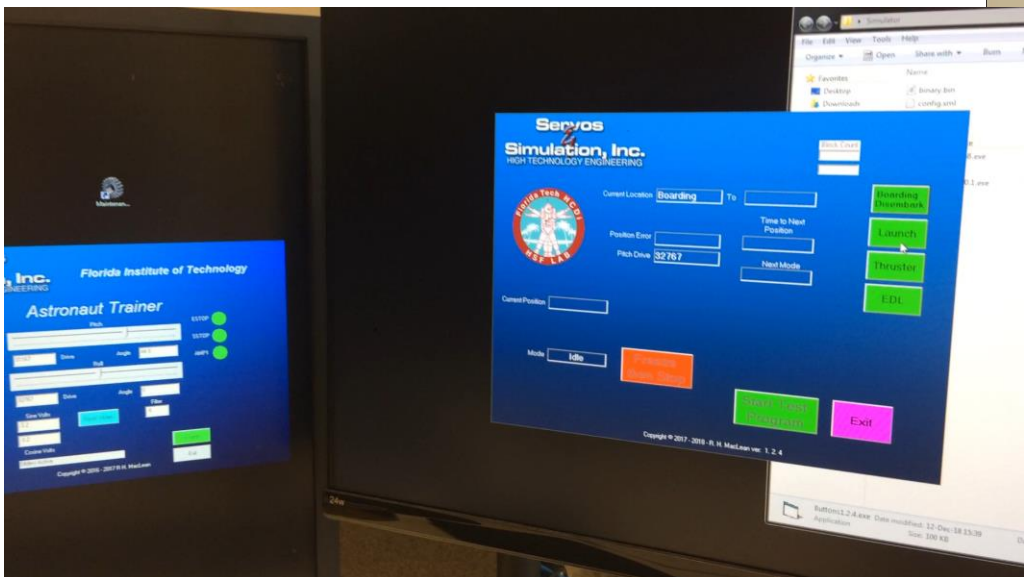
Simulating Microgravity

- Microgravity has a number of effects on astronauts and space tourists
- 23% of shuttle astronauts had near-vision changes in flight and 11% post-flight
- 48% of long-term astronauts had vision issues
 - Edema
 - Flattening
 - “wool” spots
 - Kinked optic nerves
- Intraocular pressure differences were noticed as far back as Gemini V and VII

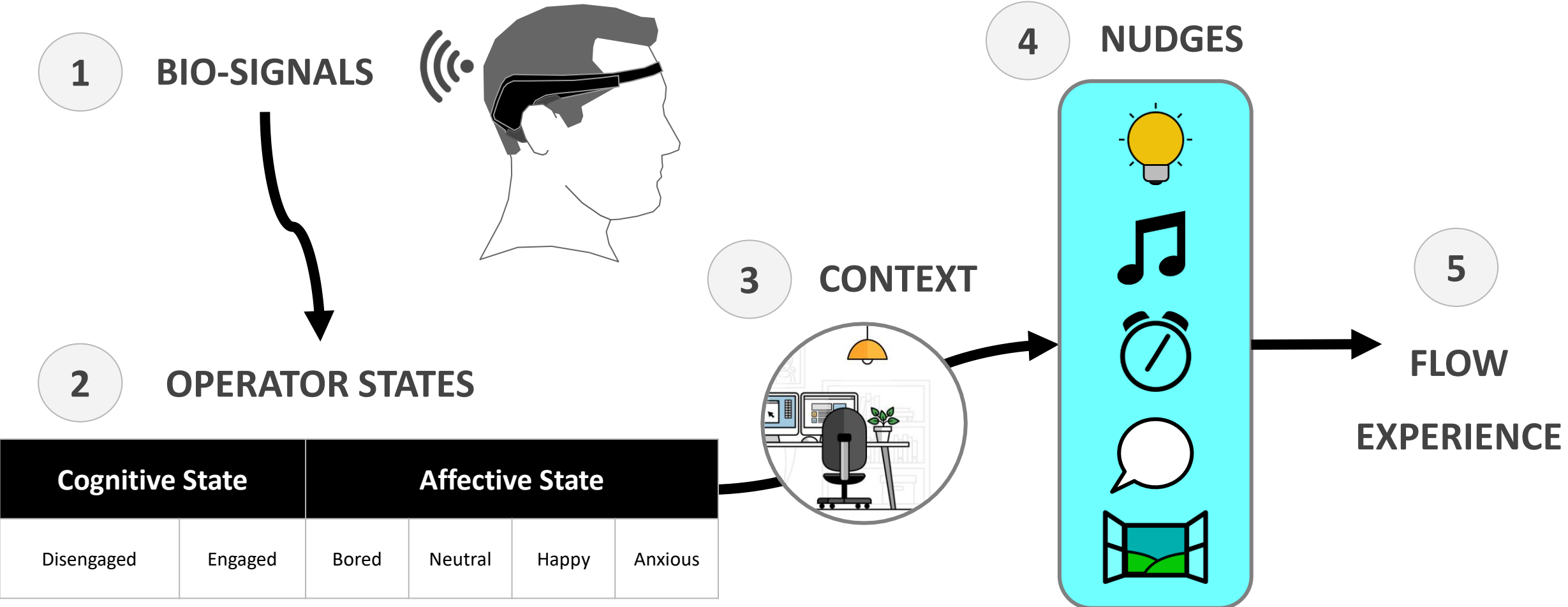


E. Seedhouse (2015), *Microgravity and Vision Impairments in Astronauts*, SpringerBriefs in Space Development, Springer International Publishing Switzerland

FIT Microgravity Simulator

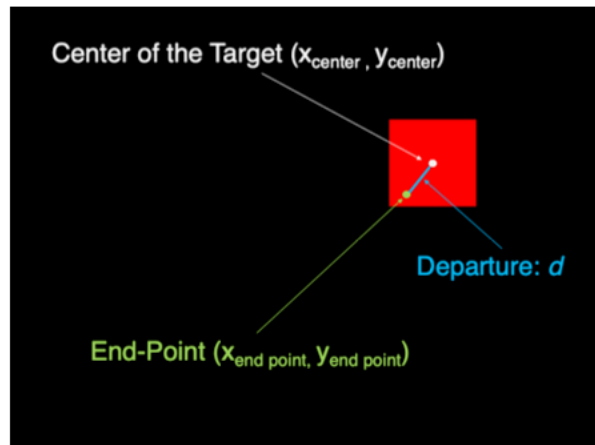
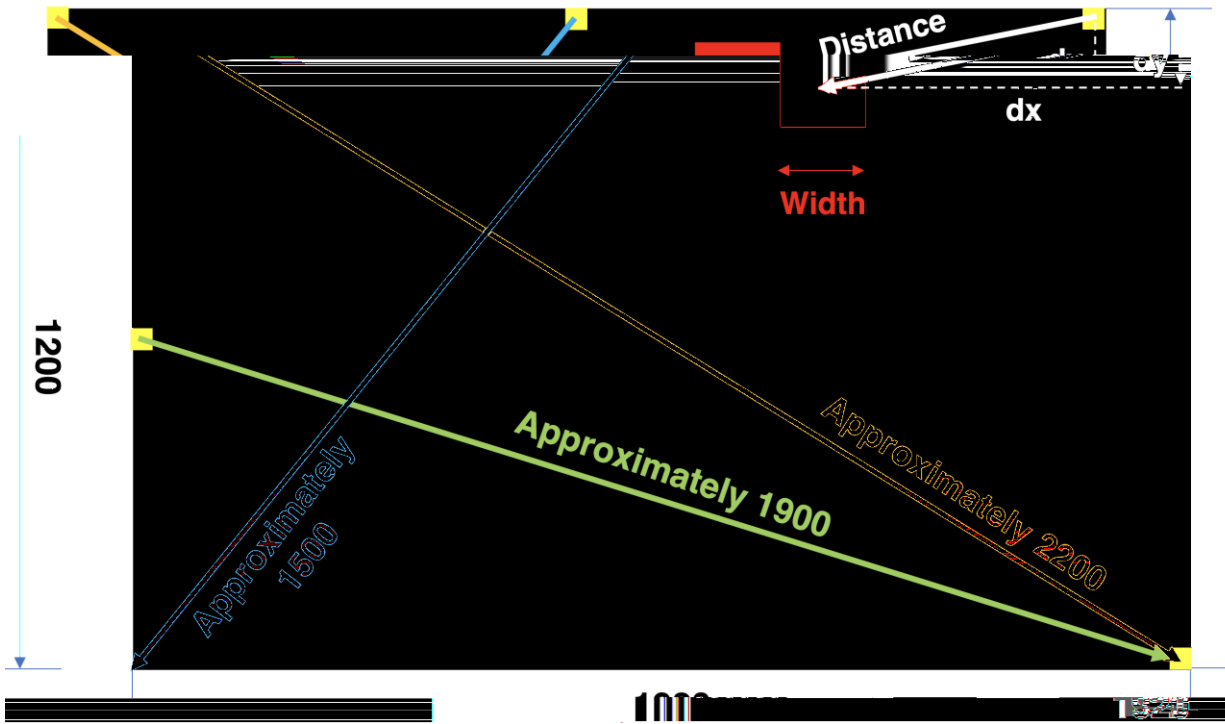


Cognitive Ergonomics



Eskridge, Thomas C, and Weekes, Troy R (2020) **Opportunities for Case-based Reasoning in Personal Flow and Productivity Management**, In *Proceedings of the 28th International Conference on Case-based Reasoning (ICCBR-2020)* 2020

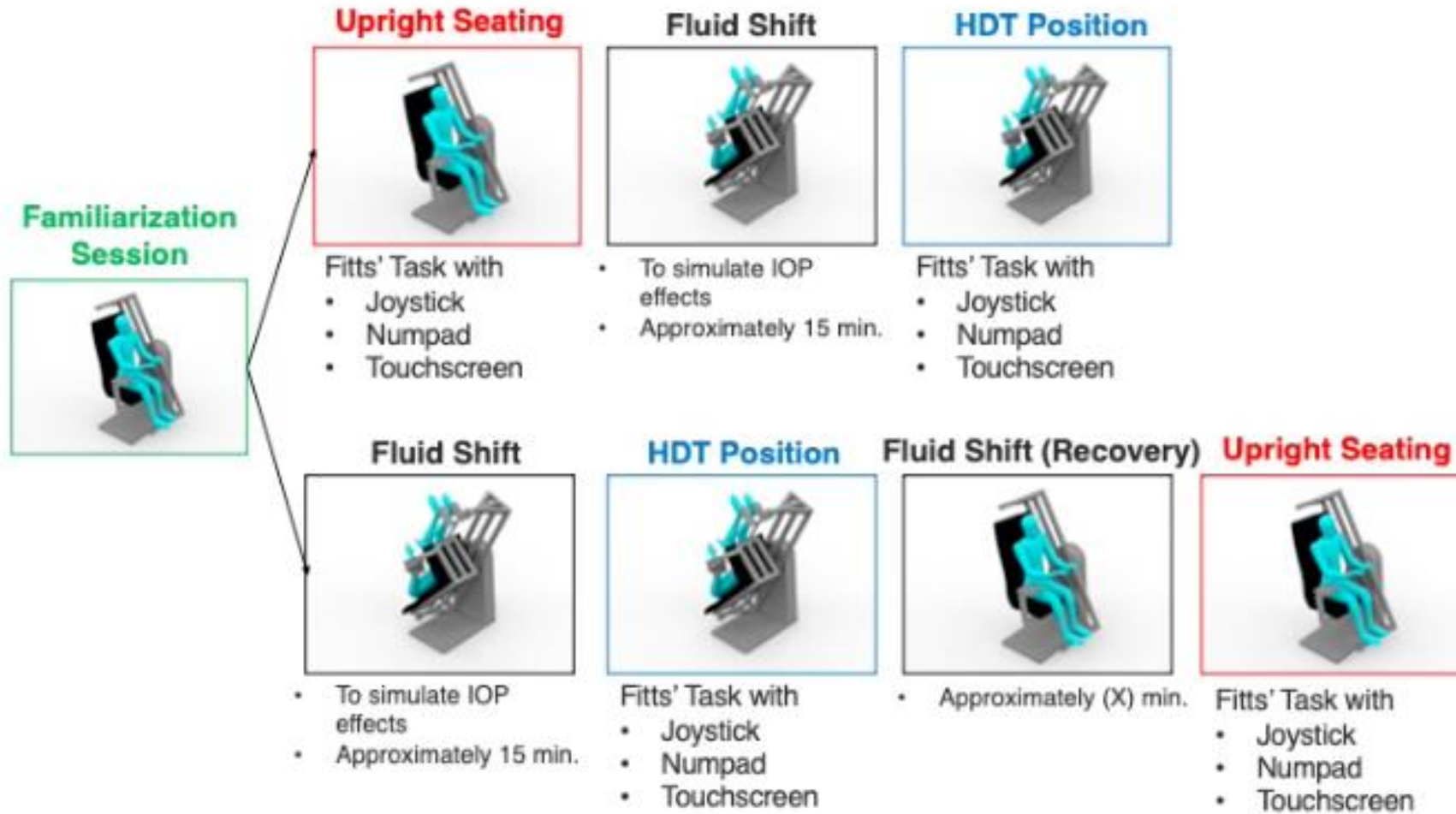
Fitt's Task



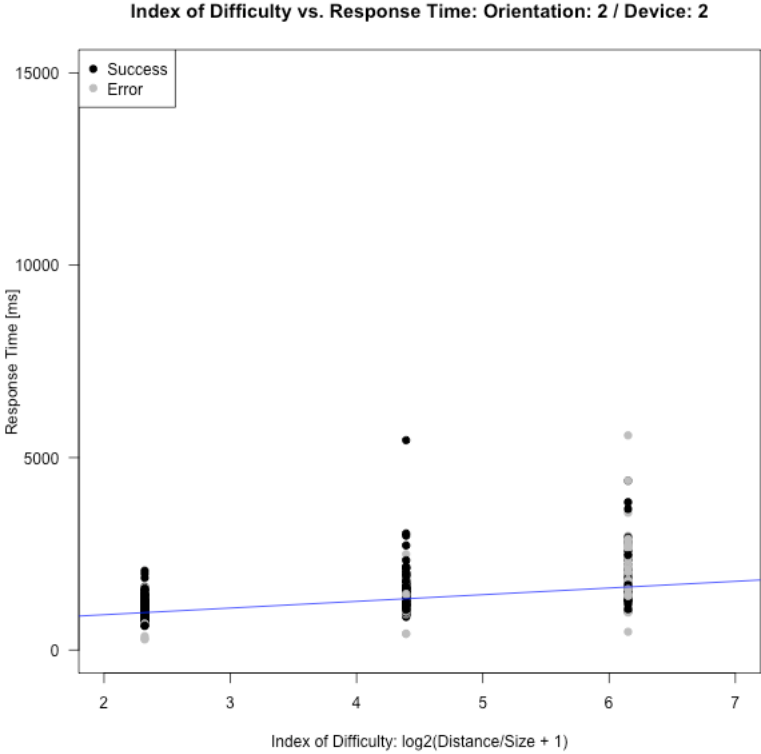
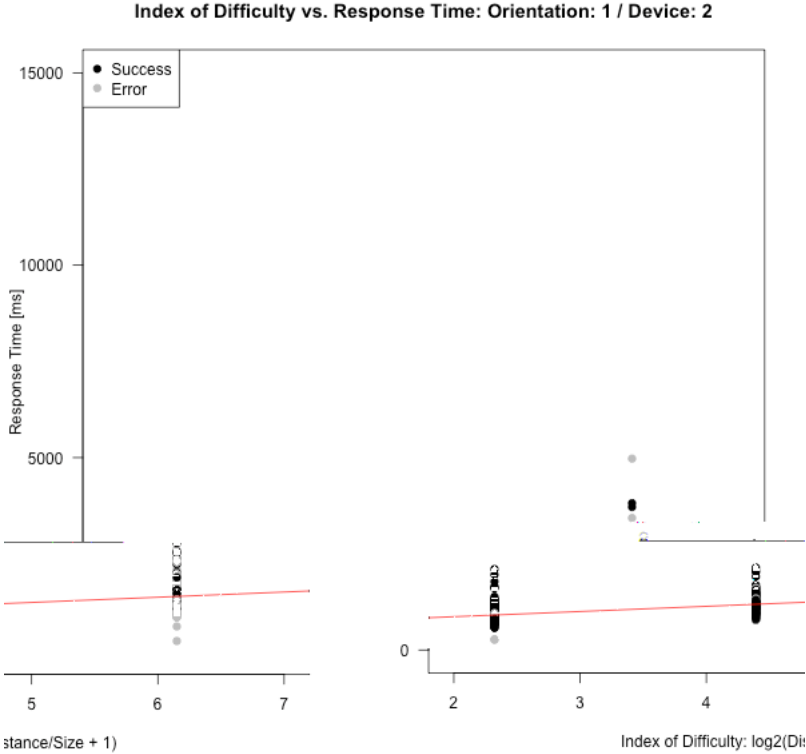
$$ID = \log_2\left(\frac{2D}{W}\right)$$

$$MT = a + bID$$

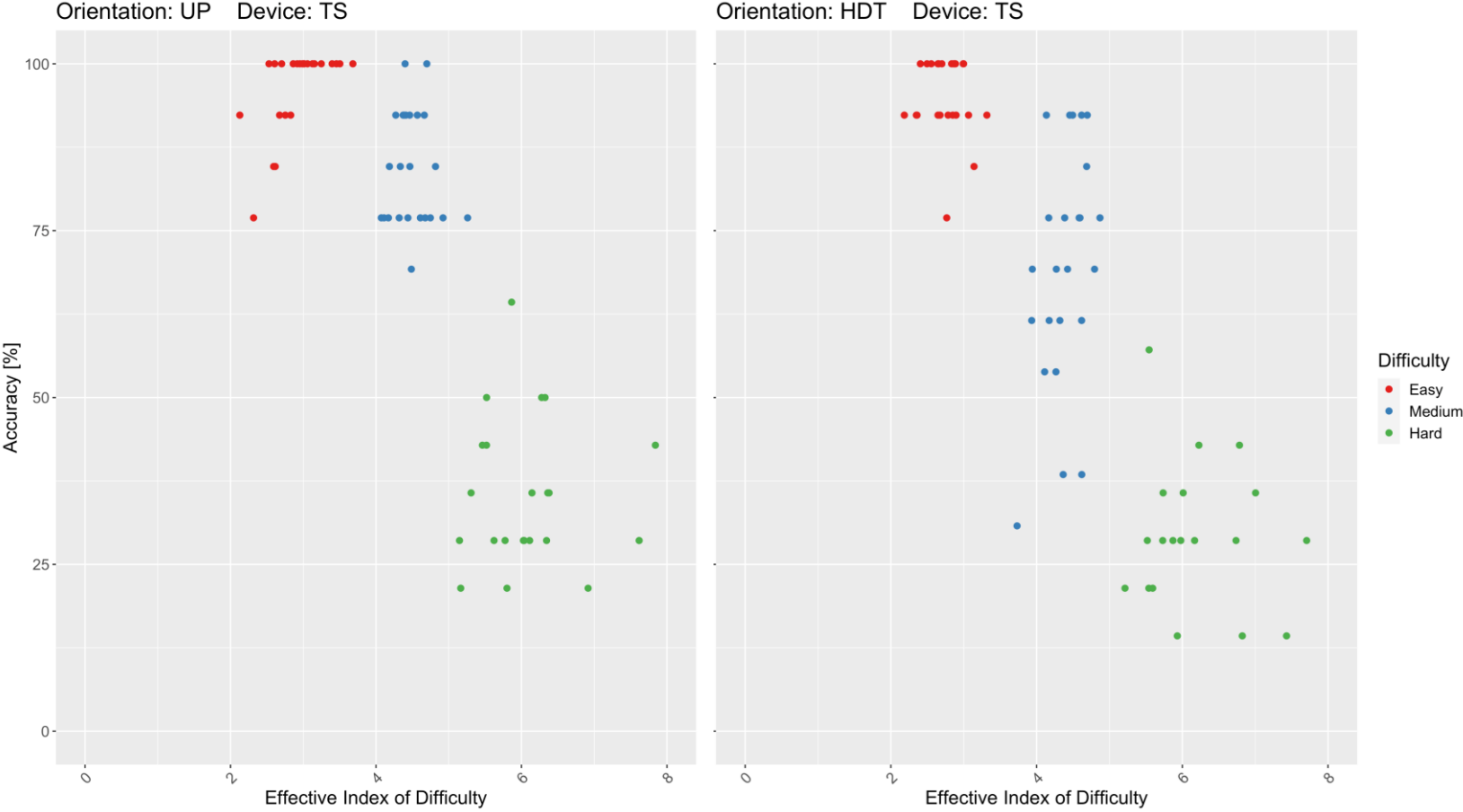
Method



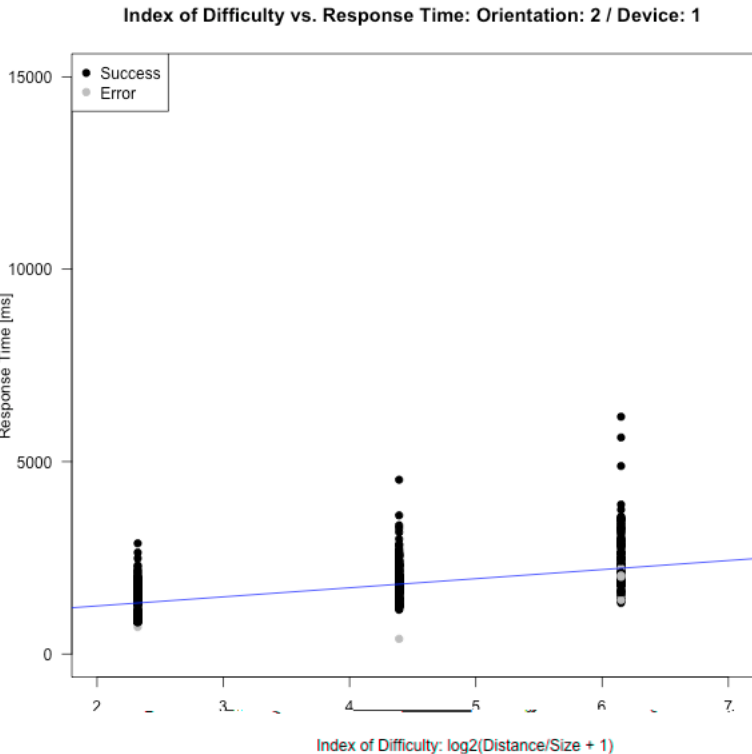
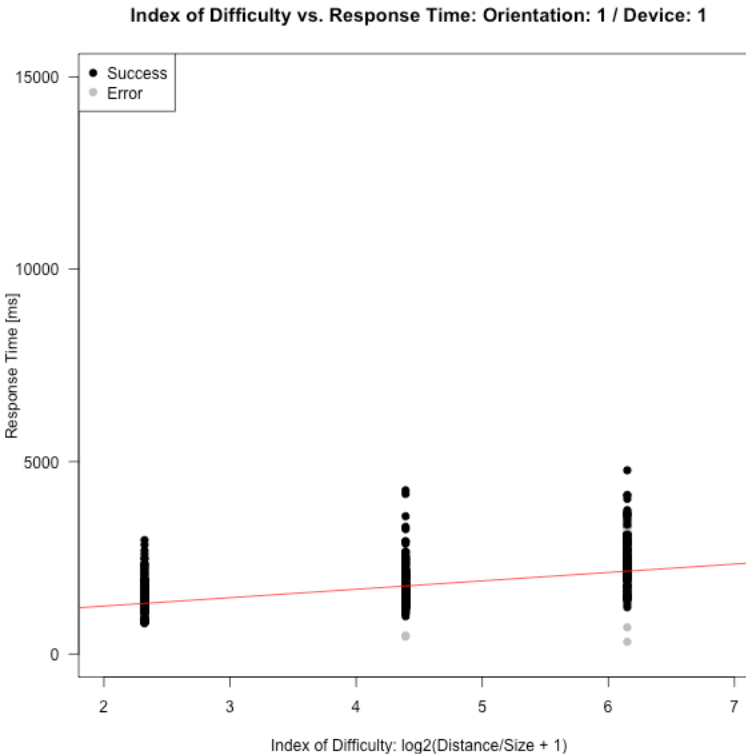
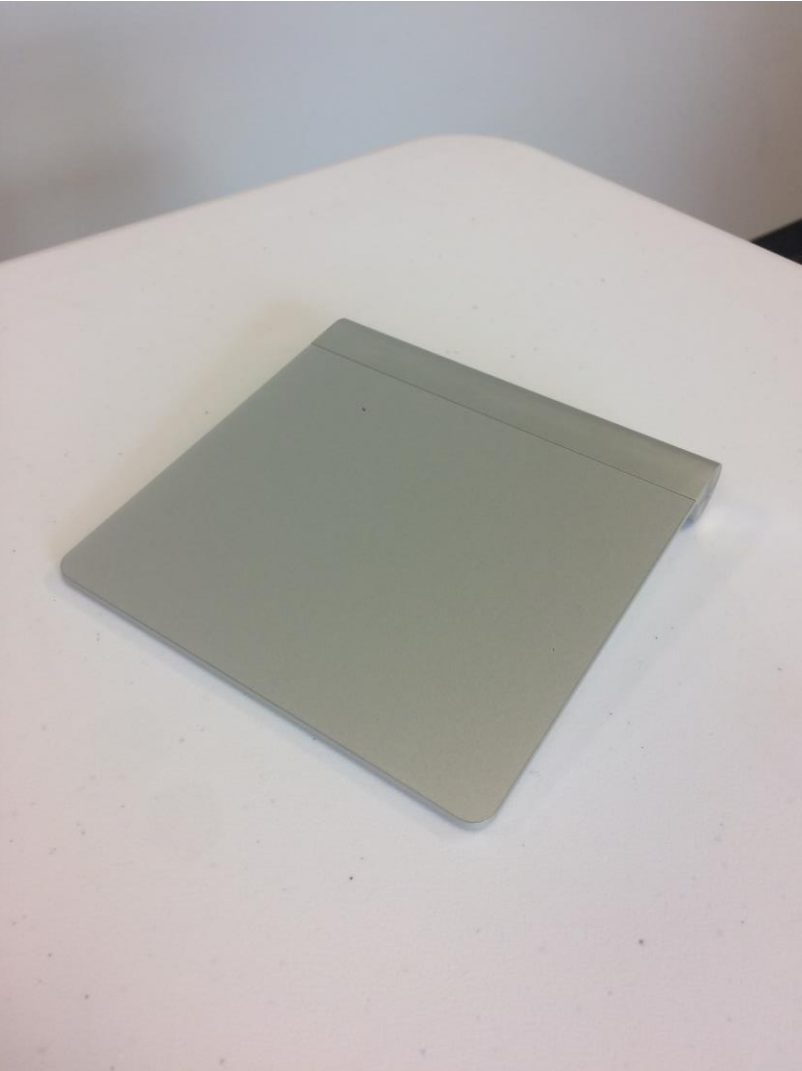
TouchScreen



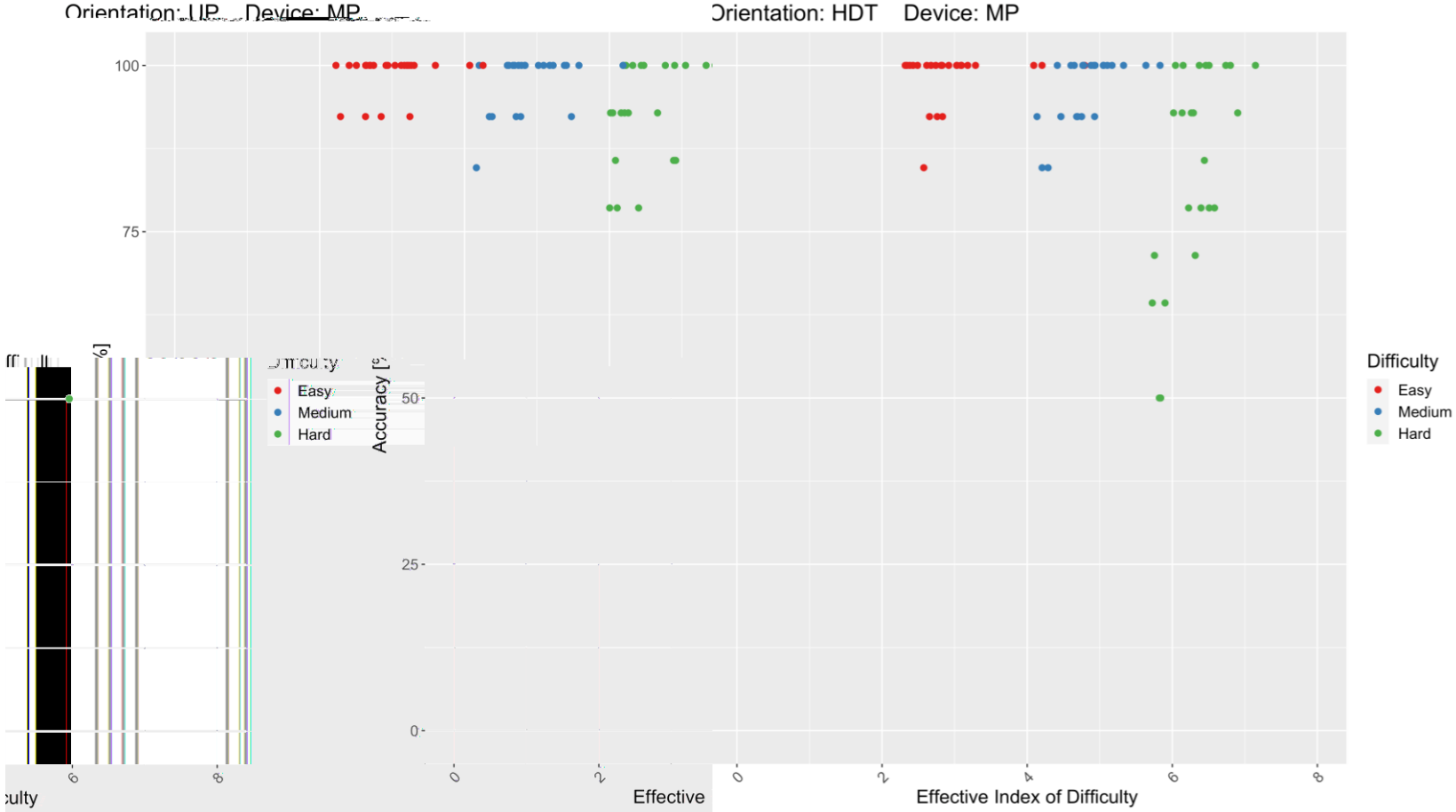
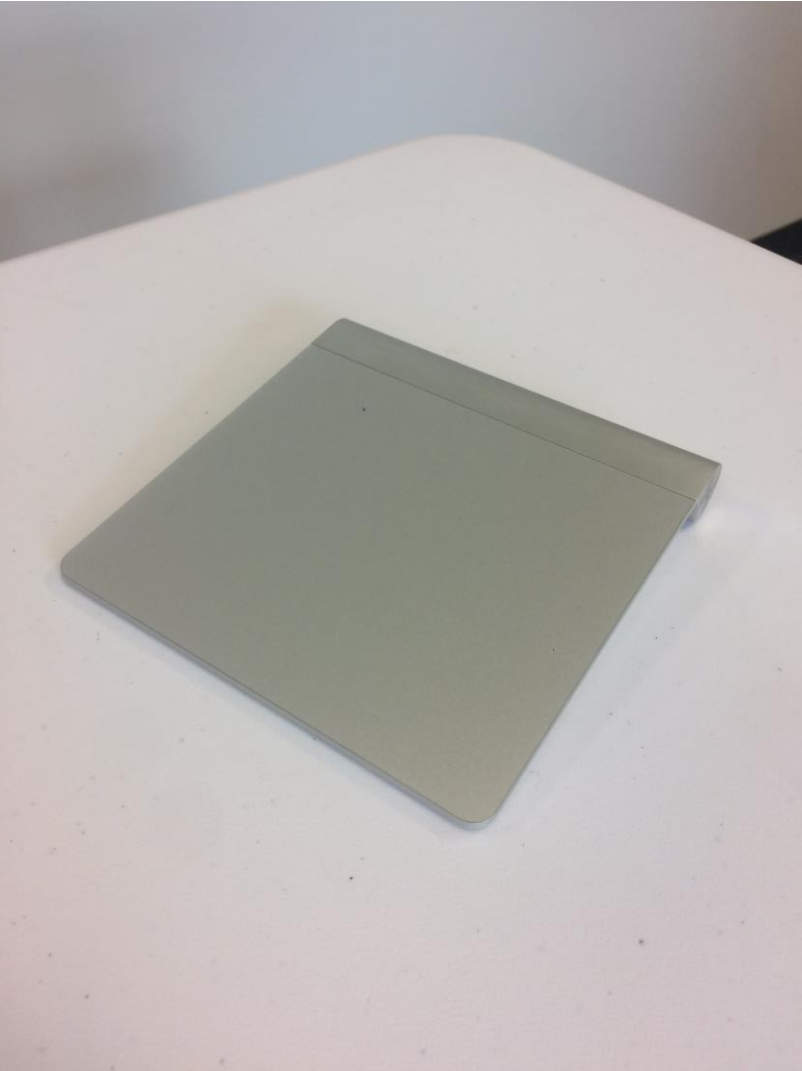
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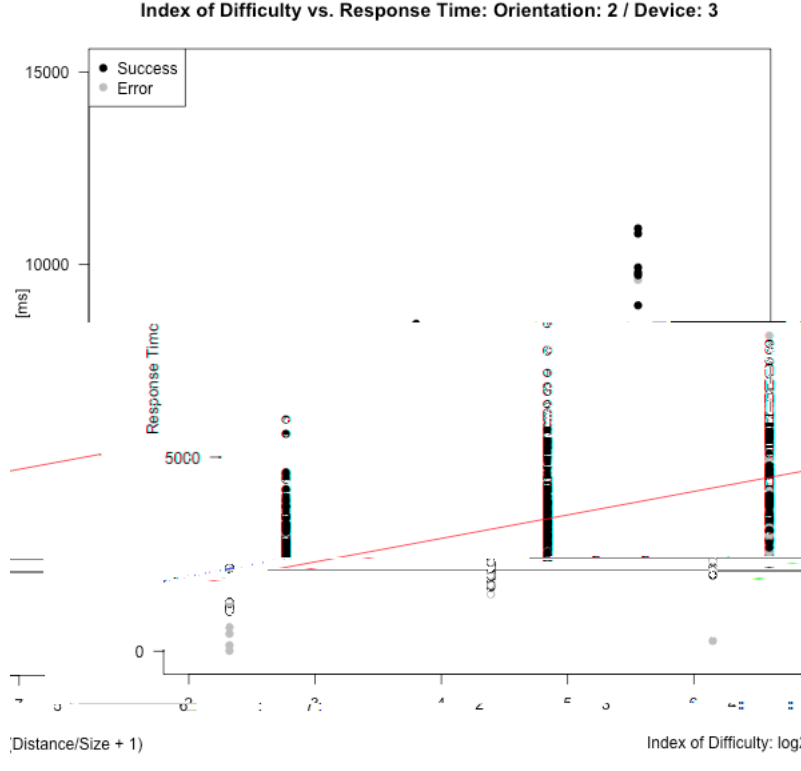
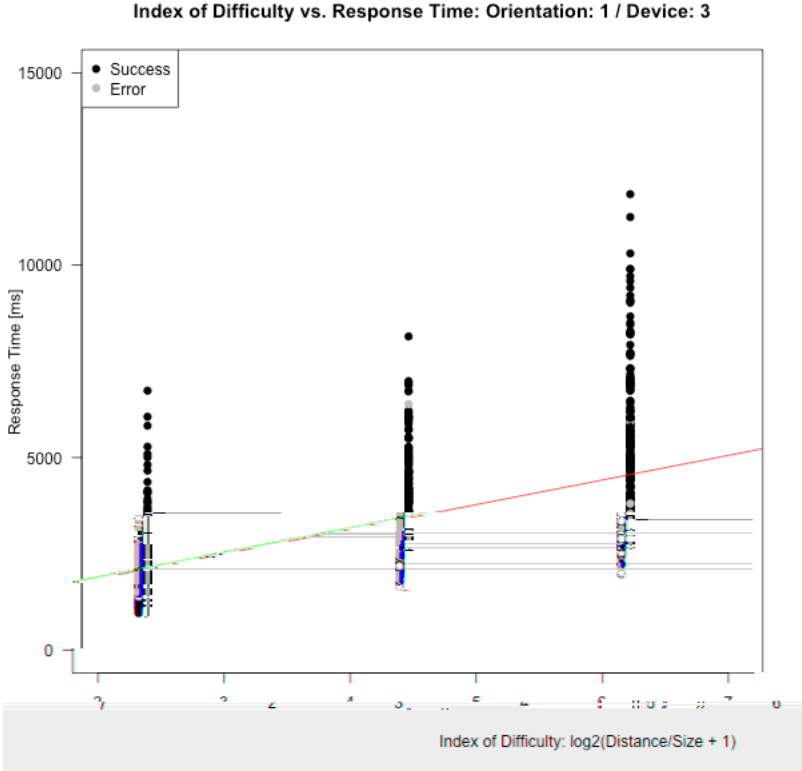
Trackpad



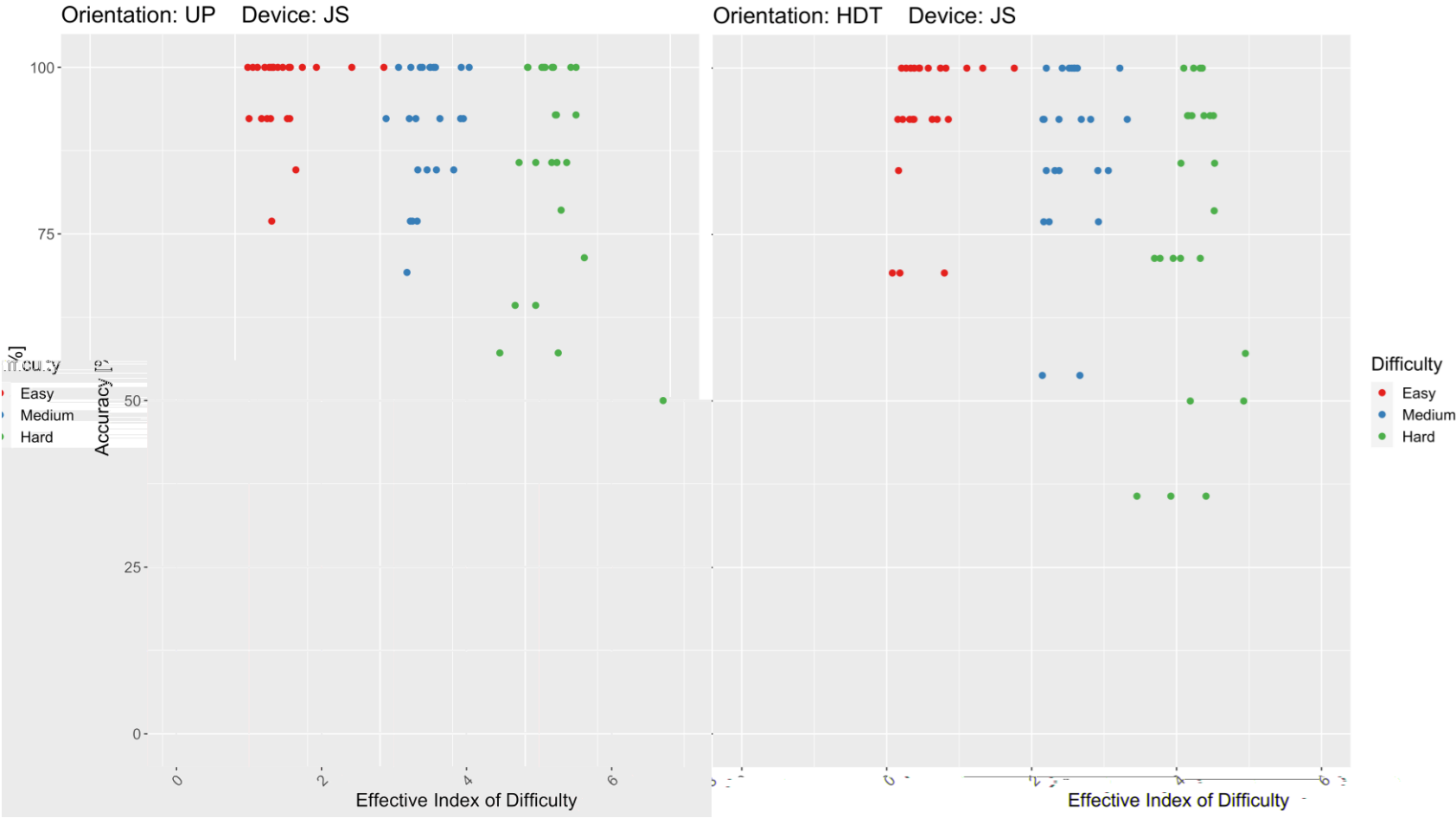
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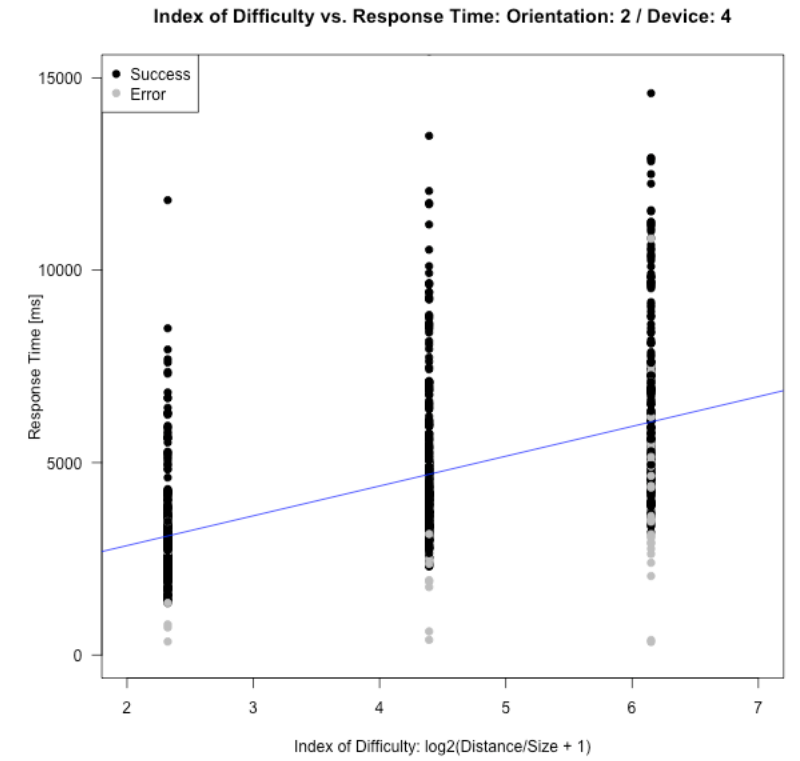
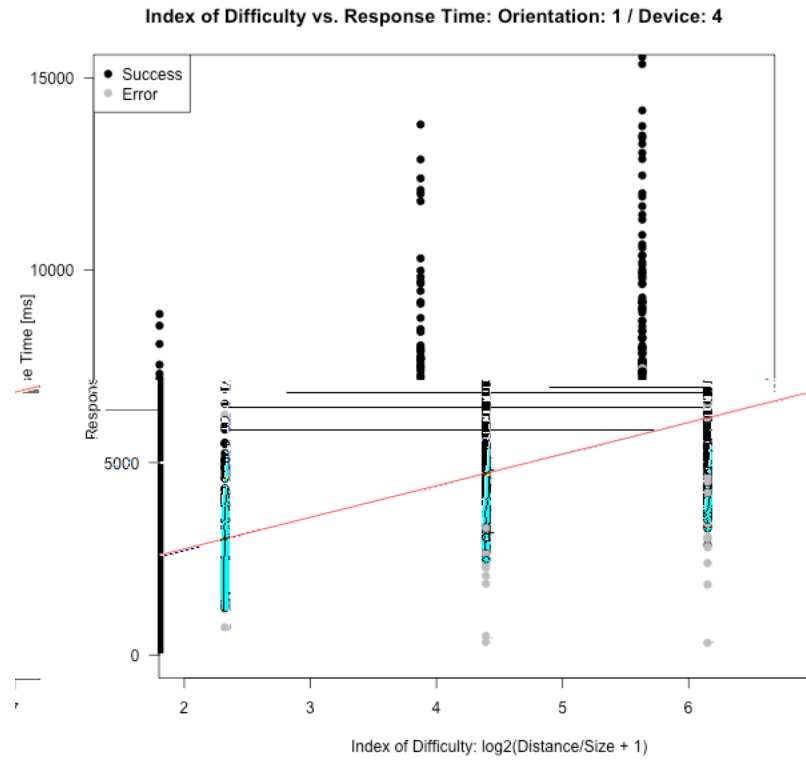
Joystick



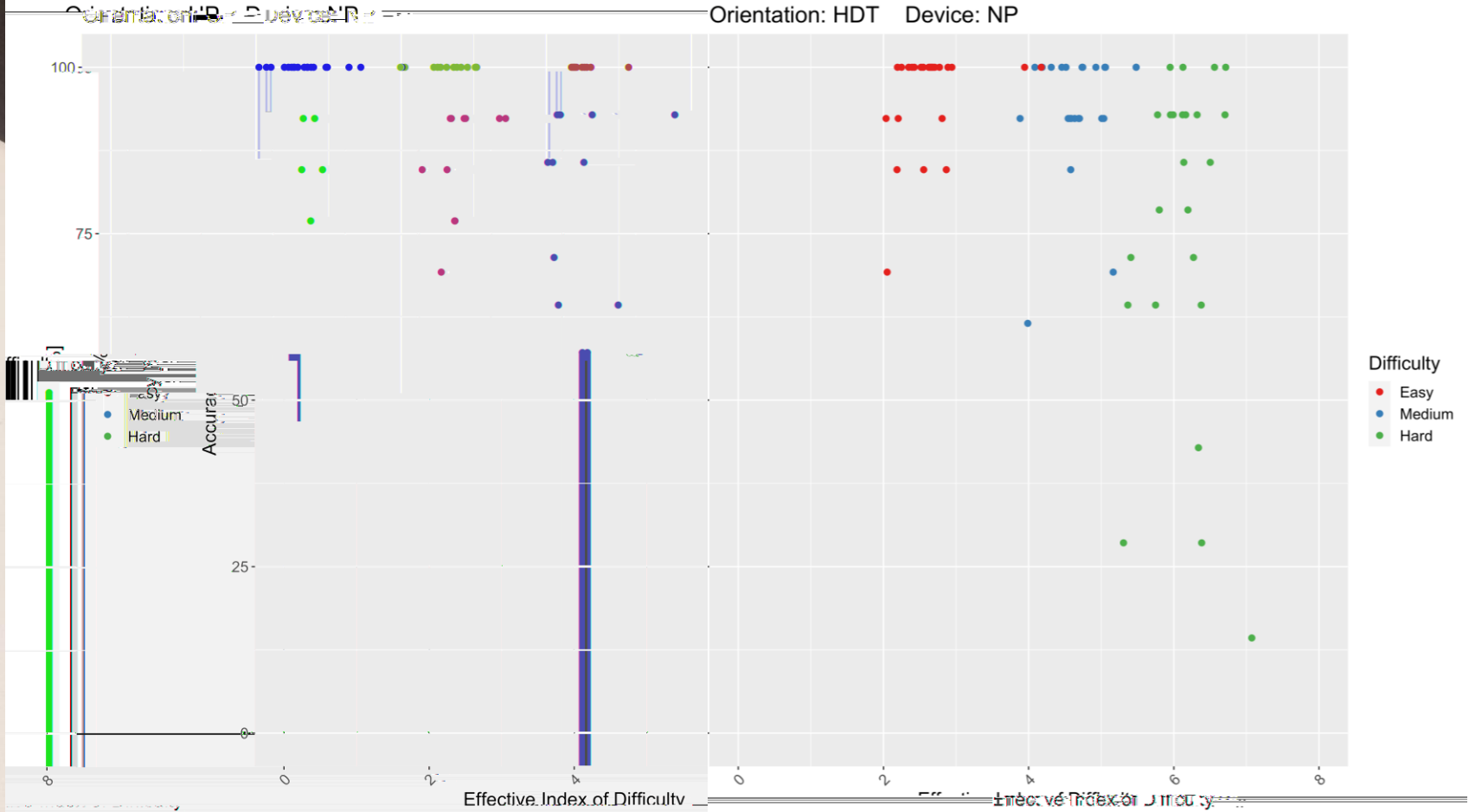
Joystick



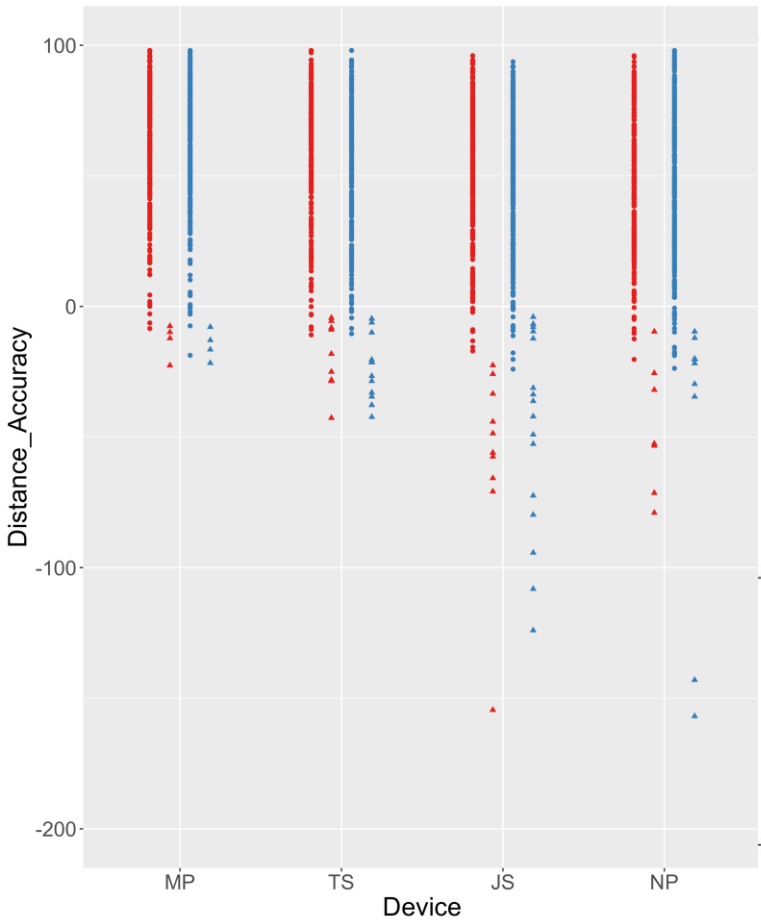
Keypad



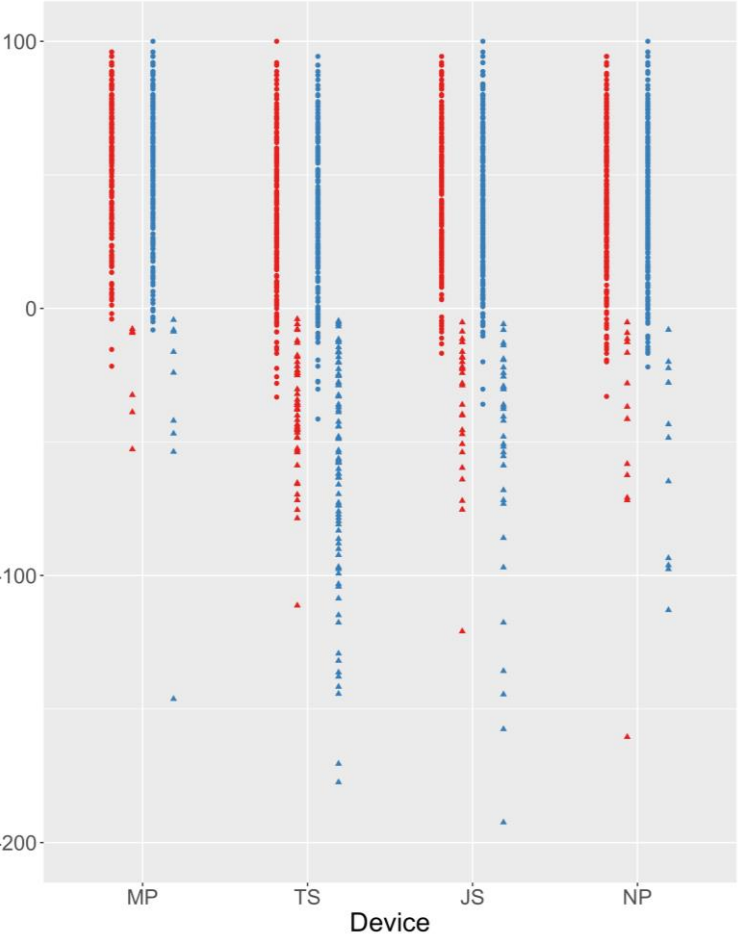
Keypad



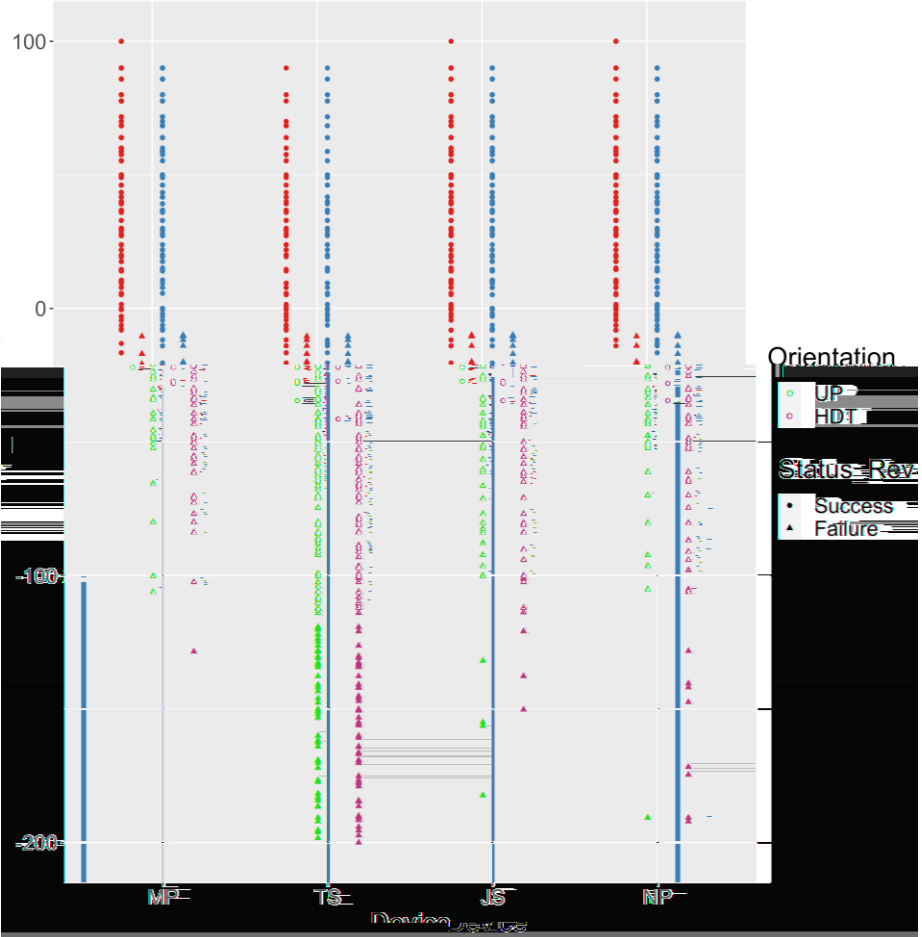
Accuracy Comparison



Easy



Medium

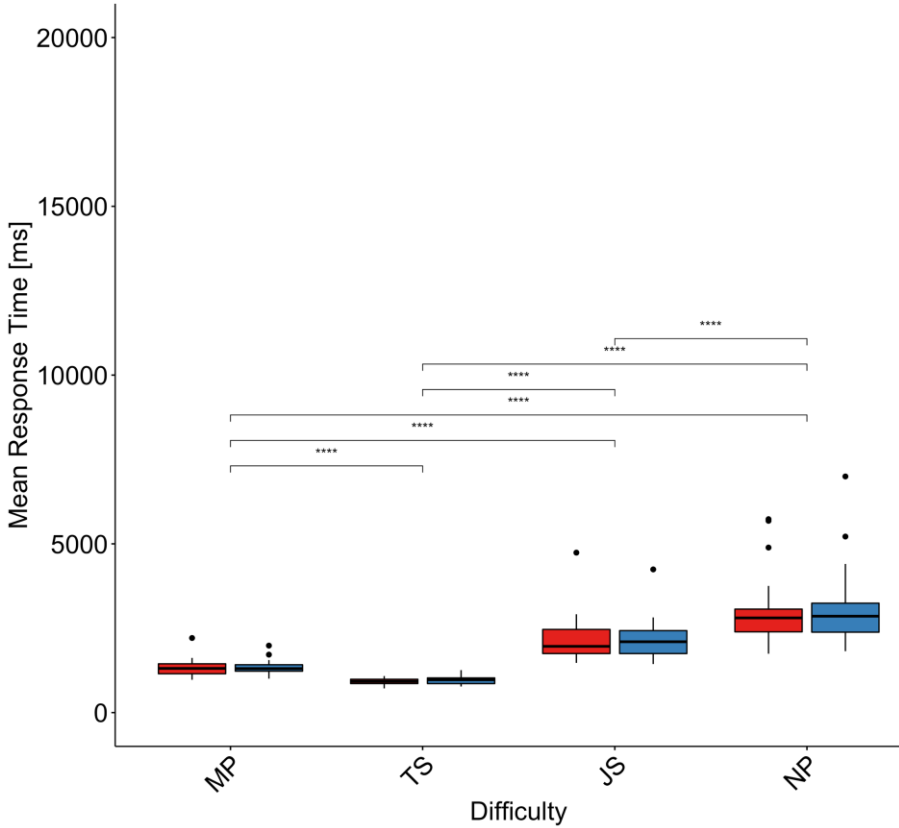


Hard

Response Time Comparison

Device and Response Time / Difficulty: Easy

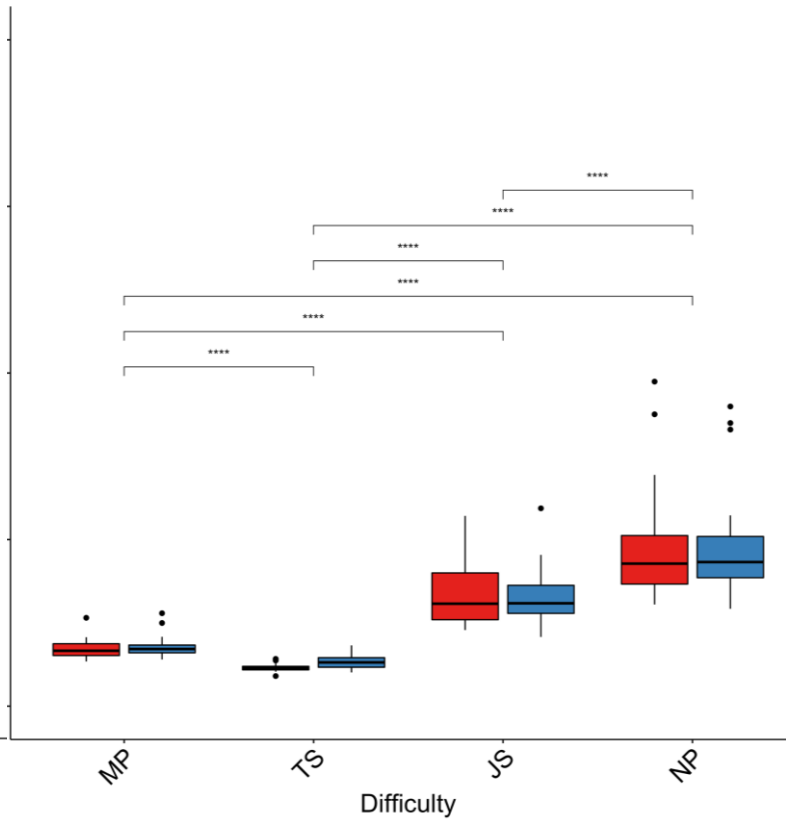
Input Device UP HDT



Easy

Device and Response Time / Difficulty: Medium

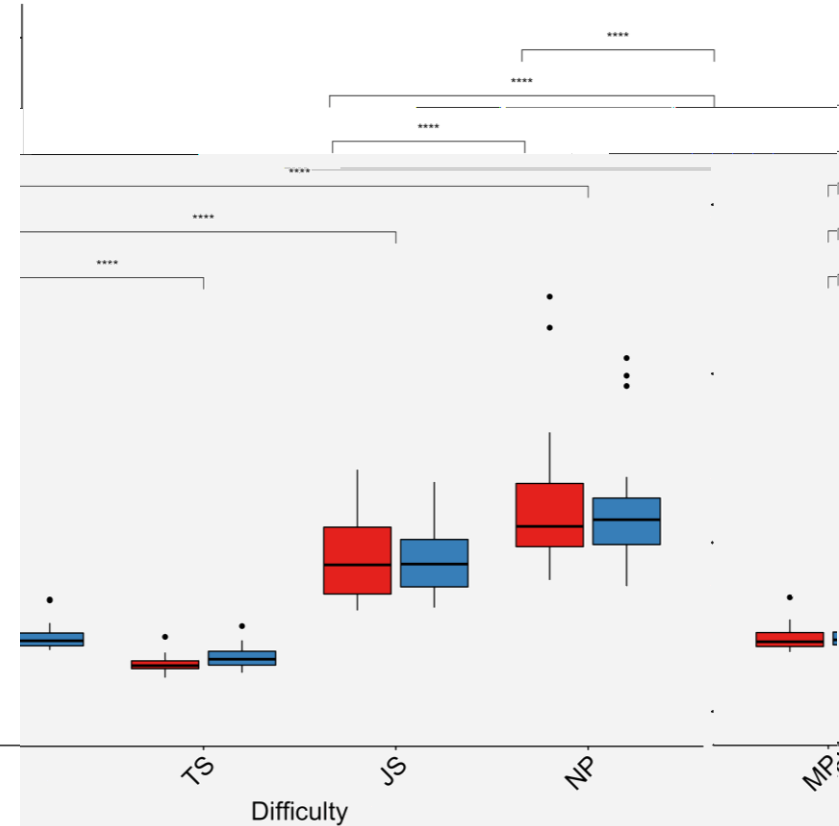
Input Device UP HDT



Medium

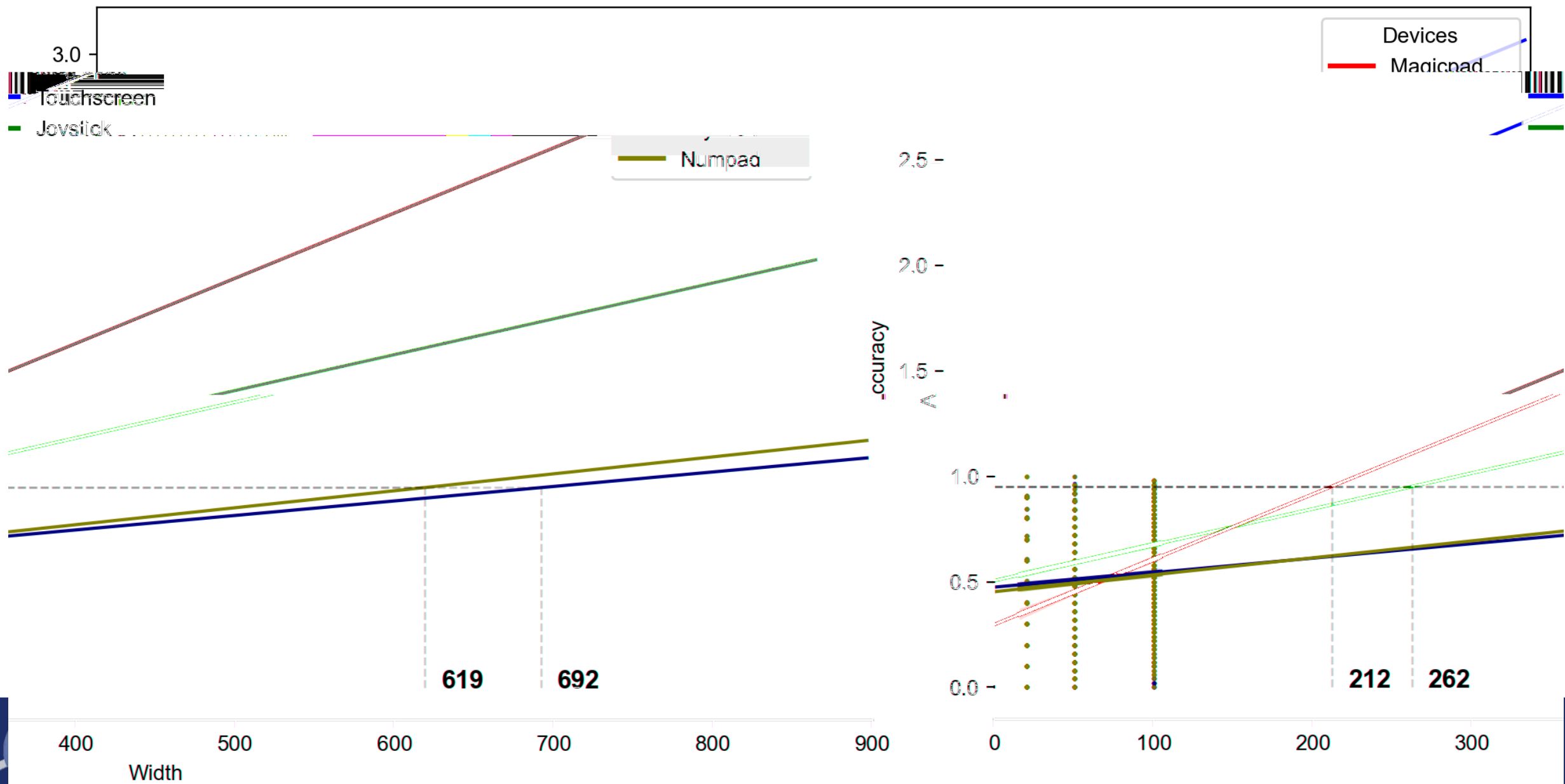
Device and Response Time / Difficulty: Hard

Input Device UP HDT



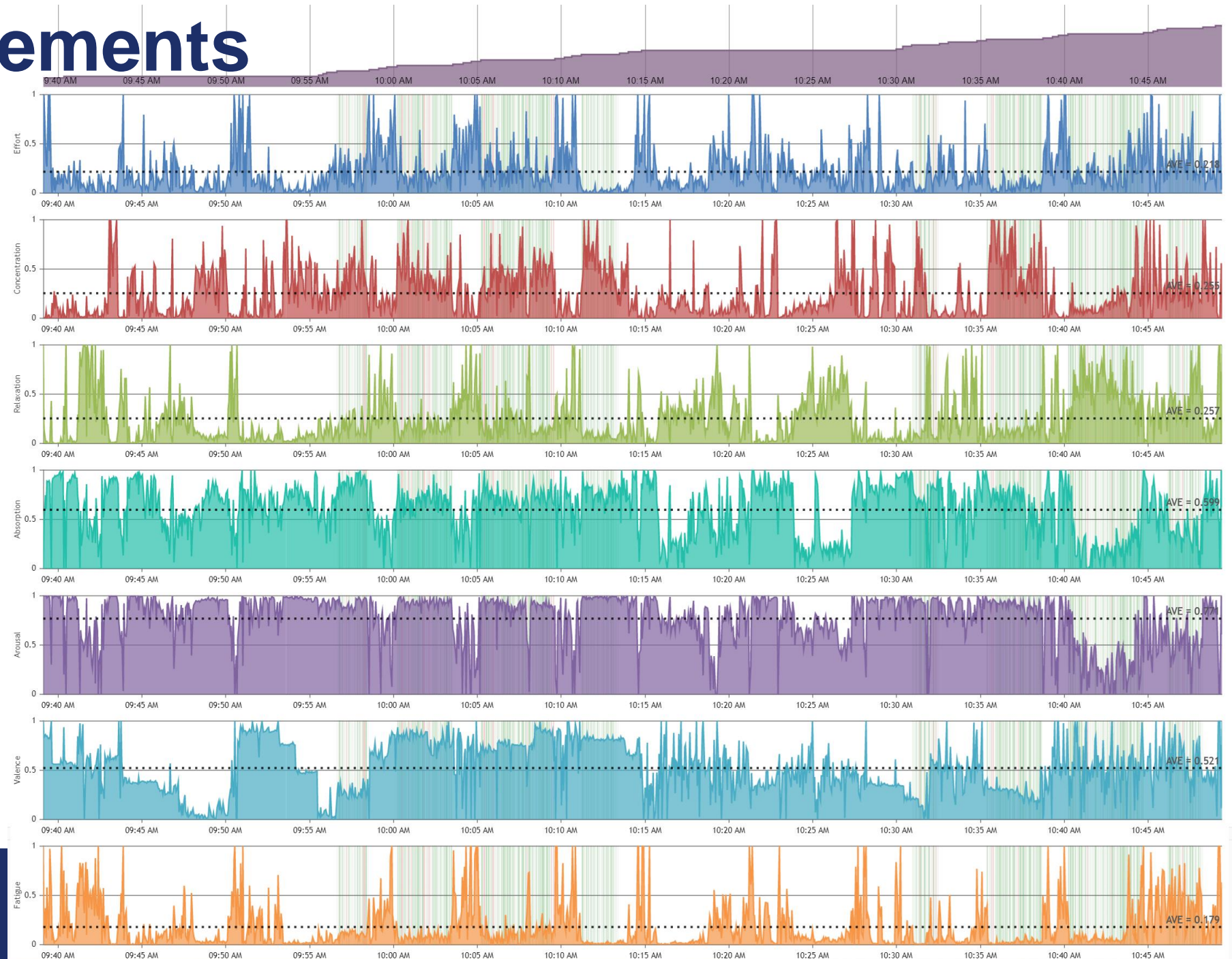
Hard

Accuracy on Width

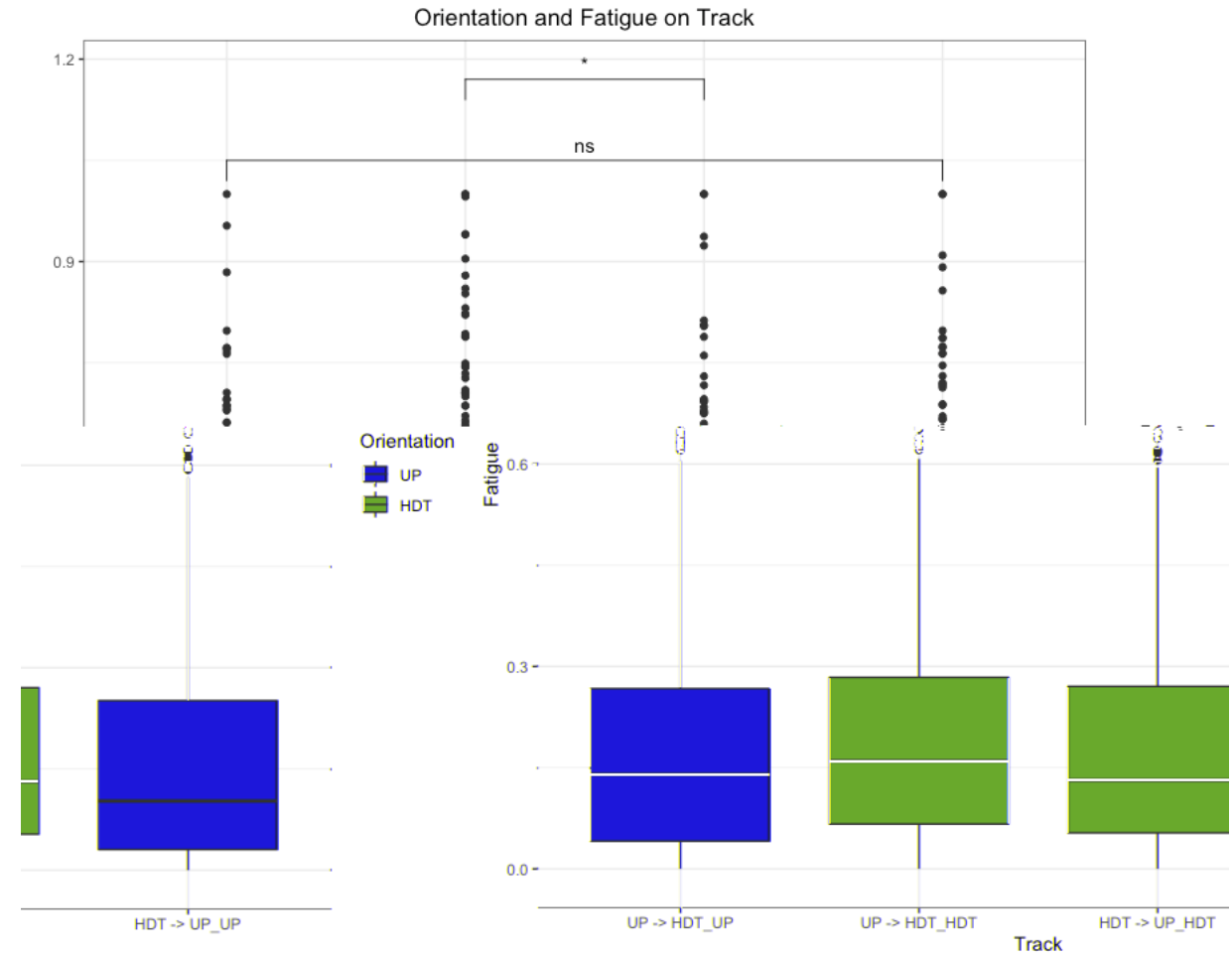
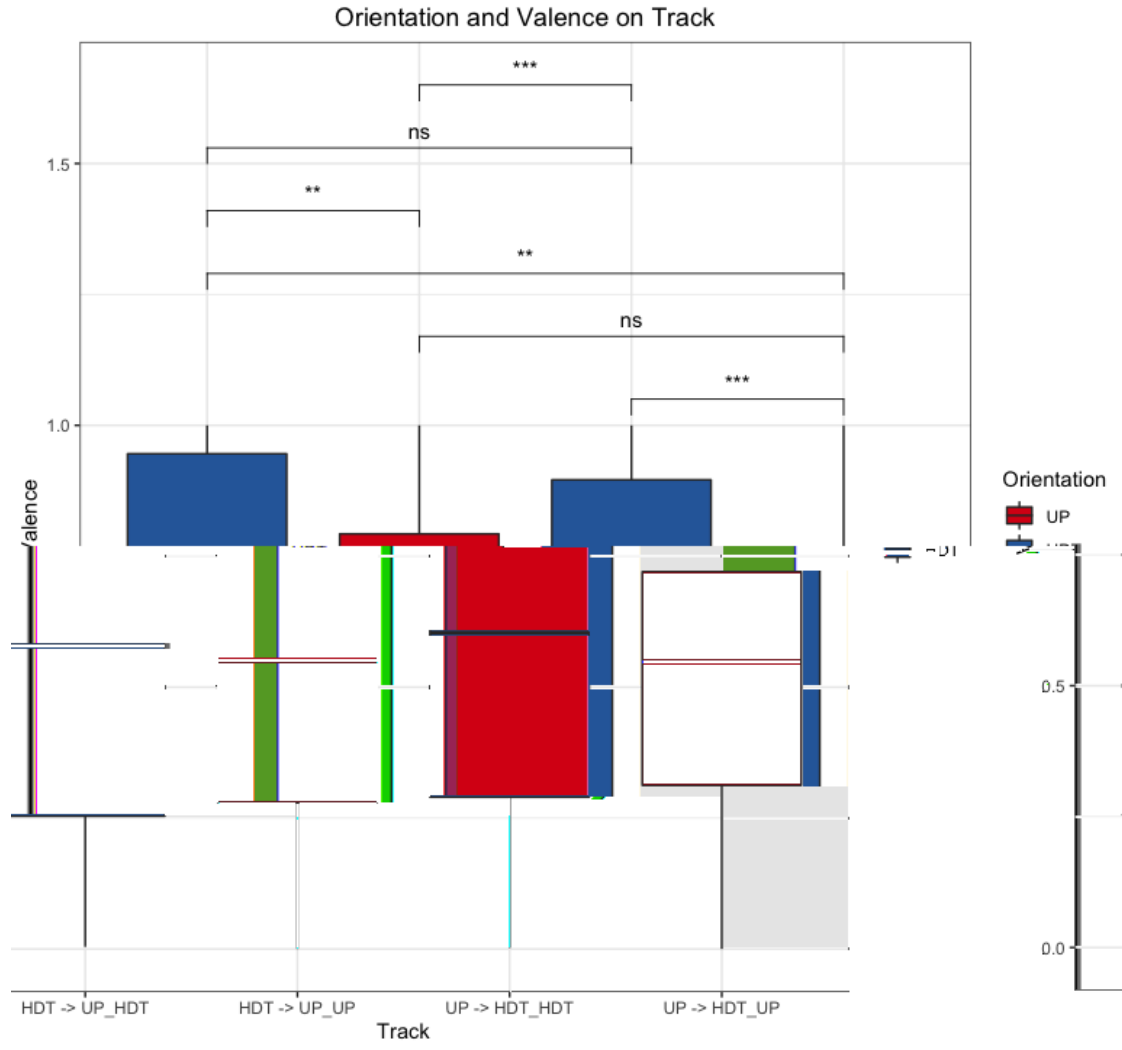


EEG Measurements

- Signals are processed into cognitive state indicators
- Shaded background areas are trial tasks



EEG Measurements





Hi, spaceflight

PREV

TUESDAY NOON, 29 MAR 22, 12:30 - 16226 RECORDS

NEXT

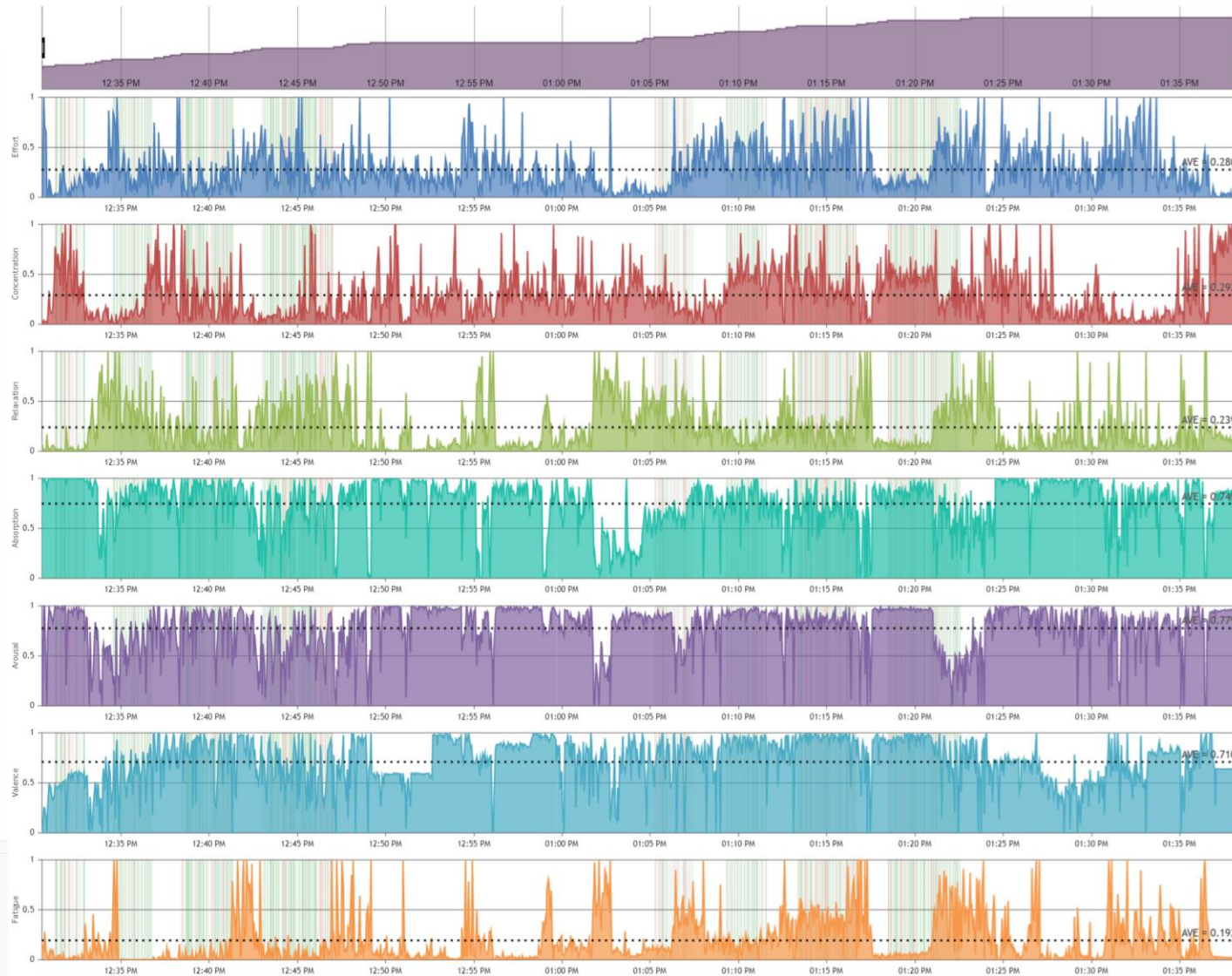
FULL SESSION

P₇ - TUESDAY NOON, 29 MAR 22, 12:30

TASKS

EVENTS

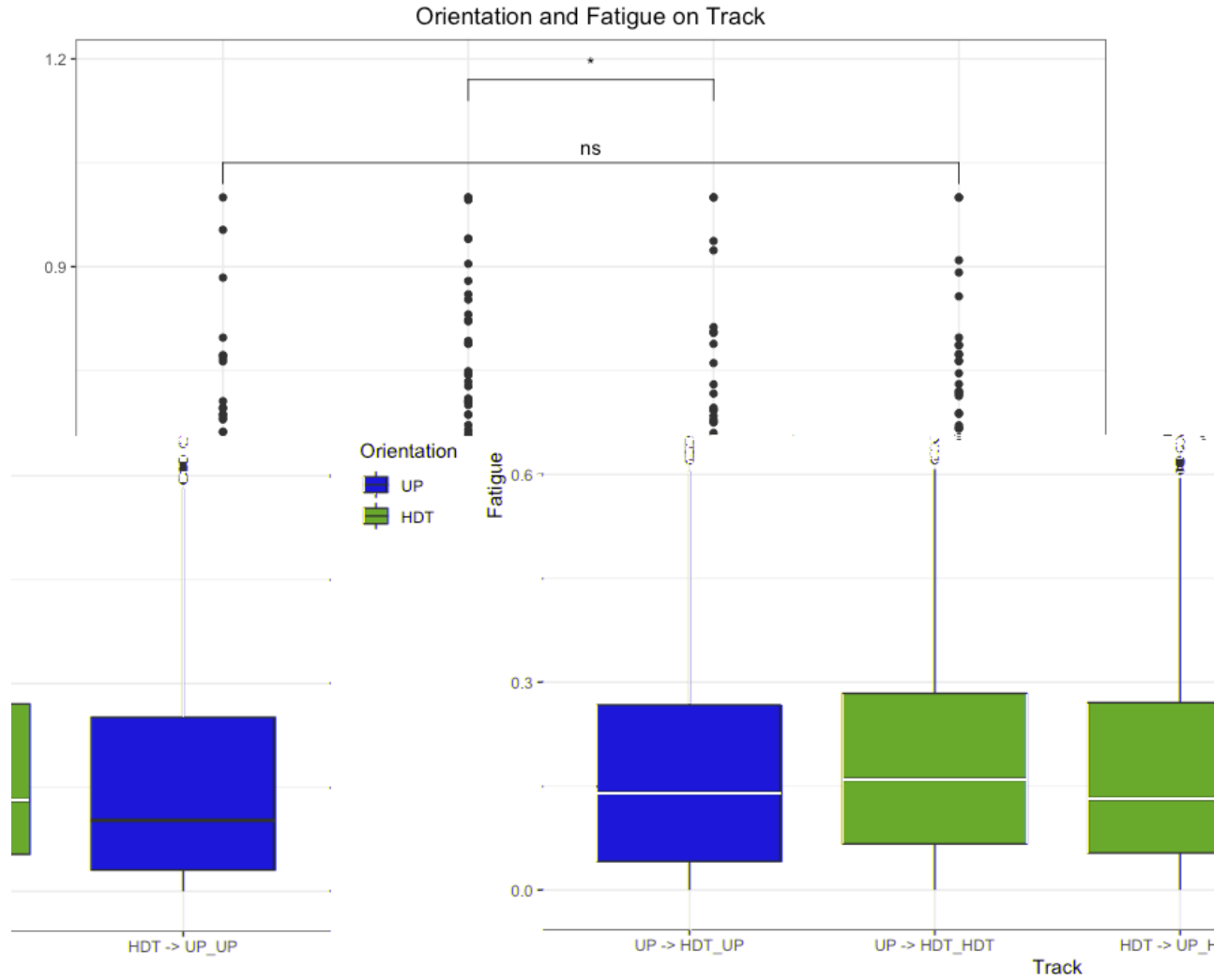
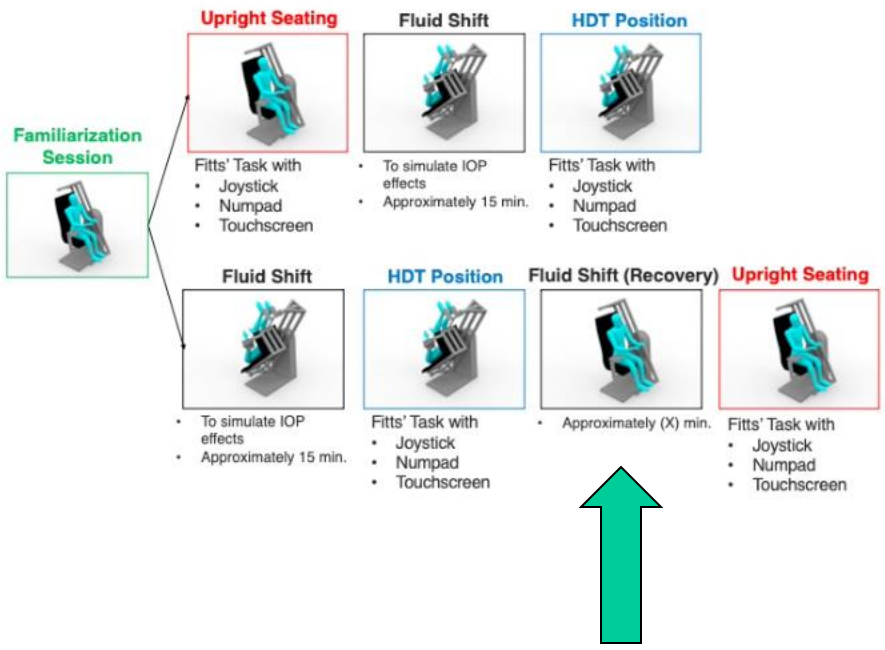
● TRIAL 1 - UP - TOUCHSCREEN - DIFFICULT - FAILURE	1255.0 MS
● TRIAL 2 - UP - TOUCHSCREEN - MEDIUM - SUCCESS	1170.0 MS
● TRIAL 3 - UP - TOUCHSCREEN - EASY - SUCCESS	993.0 MS
● TRIAL 4 - UP - TOUCHSCREEN - EASY - SUCCESS	1196.0 MS
● TRIAL 5 - UP - TOUCHSCREEN - MEDIUM - SUCCESS	1010.0 MS
● TRIAL 6 - UP - TOUCHSCREEN - DIFFICULT - FAILURE	1116.0 MS
● TRIAL 7 - UP - TOUCHSCREEN - DIFFICULT - FAILURE	1229.0 MS
● TRIAL 8 - UP - TOUCHSCREEN - DIFFICULT - SUCCESS	1229.0 MS
● TRIAL 9 - UP - TOUCHSCREEN - MEDIUM - SUCCESS	1122.0 MS
● TRIAL 10 - UP - TOUCHSCREEN - DIFFICULT - FAILURE	1207.0 MS
● TRIAL 11 - UP - TOUCHSCREEN - MEDIUM - SUCCESS	1010.0 MS
● TRIAL 12 - UP - TOUCHSCREEN - DIFFICULT - FAILURE	1139.0 MS
● TRIAL 13 - UP - TOUCHSCREEN - EASY - SUCCESS	1097.0 MS
● TRIAL 14 - UP - TOUCHSCREEN - EASY - SUCCESS	1085.0 MS
● TRIAL 15 - UP - TOUCHSCREEN - MEDIUM - SUCCESS	1027.0 MS
● TRIAL 16 - UP - TOUCHSCREEN - EASY - SUCCESS	1016.0 MS
● TRIAL 17 - UP - TOUCHSCREEN - EASY - SUCCESS	821.0 MS
● TRIAL 18 - UP - TOUCHSCREEN - MEDIUM - SUCCESS	1112.0 MS



Fatigue during trials



Limitations of the Study



Publications, Presentations, Awards, & Recognitions

RELATED PUBLICATIONS

Momose, K., Weekes, T.R., and Eskridge, T.C.(2021). Human-Centered Design for Spaceflight Participant Safety and Experience: A Case Study of Blue Origin Suborbital Flight. *New Space Journal*, online 11 Nov 2021.

<https://doi.org/10.1089/space.2021.0029>

<https://www.liebertpub.com/doi/10.1089/space.2021.0029>

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Preprint, 2021
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Mary Ann Liebert, Inc.  publishers

Original Article

Human-Centered Design for Spaceflight Participant Safety and Experience: A Case Study of Blue Origin Suborbital Flight

Kazuhiko Momose¹, Troy R. Weekes¹, and Thomas C. Eskridge^{1,2}

Conclusions and Future Work

- This approach allows for inclusion of speed and accuracy in determining size/distance recommendations
- Differences in HDT mean that designs need to include microgravity differences in perception
- Testing also reveals the effects of fatigue on speed and accuracy, which can enable adaptive automation
- Collecting in-suit trials
- Continuing to analyze data
- Final reporting and publication