

## **Straight Ahead in Microgravity**

**G Clément<sup>1</sup>, EE Caldwell<sup>2</sup>, MF Reschke<sup>3</sup>, SJ Wood<sup>3</sup>**

<sup>1</sup> Lyon Neuroscience Research Center, Bron, France

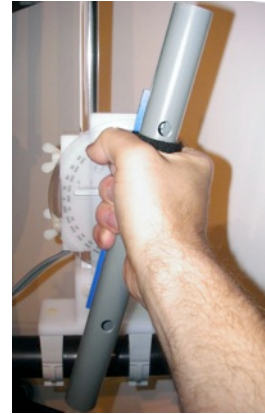
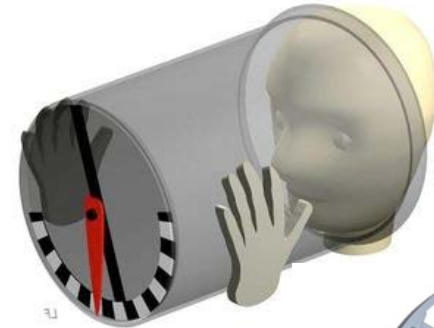
<sup>2</sup> KBR, Houston TX

<sup>3</sup> NASA Johnson Space Center, Houston TX

Study supported by Centre National d'Etudes Spatiales, ESA Human Spaceflight Office, and NASA's Human Research Program Human Health Countermeasures Element

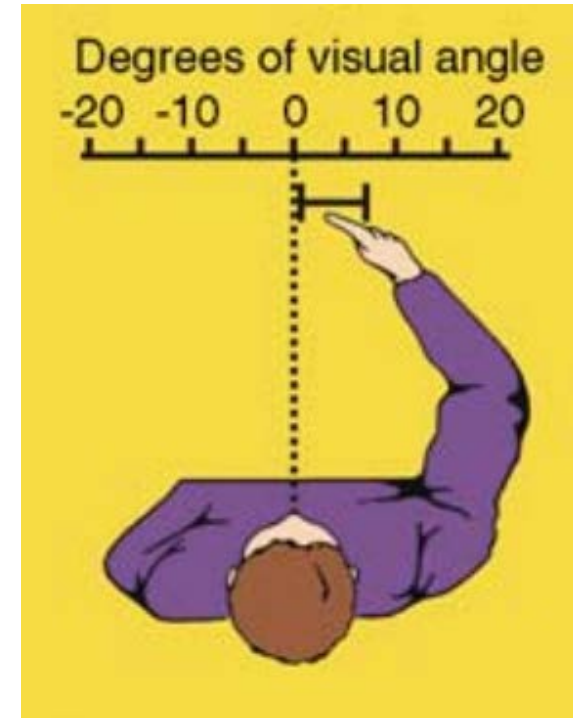
# Spatial Orientation Perception Tests

- **Subjective haptic vertical** – subjects with the eyes closed orient a bar in the Earth-vertical position
- **Subjective visual vertical** – subjects in darkness align a luminous bar along the perceived Earth-vertical
- **Subjective postural vertical** – subjects in darkness in a tilting apparatus report when they feel their body is oriented in the Earth-vertical position
- **Subjective straight ahead** – subjects in darkness point with the arm or gaze to the position they perceive as straight ahead



# Subjective Straight Ahead (SSA)

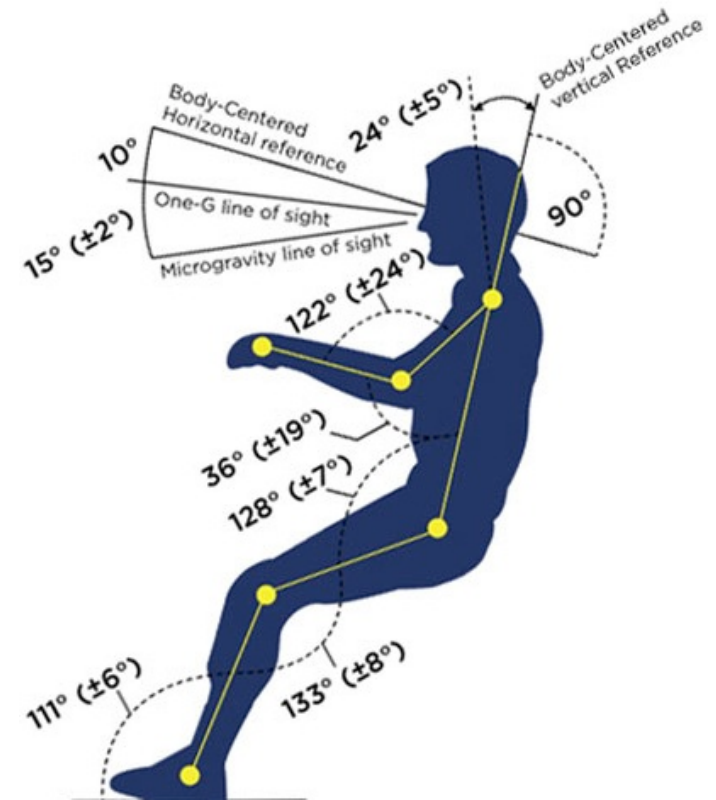
- Subjective straight-ahead (SSA) is the perceived projection of the **body midline** (head and trunk)
- **Egocentric** frame of reference
- When pointing with the arm at a body-centered line, the SSA is systematically **deviated** toward the arm by  $4^\circ \pm 4^\circ$
- When pointing with the gaze, the SSA is **aligned** with the body midline ( $\pm 2^\circ$ )



*Striemer & Danckert  
(2010) Trends Cog Sci  
14: 308-316*

# Hypothesis

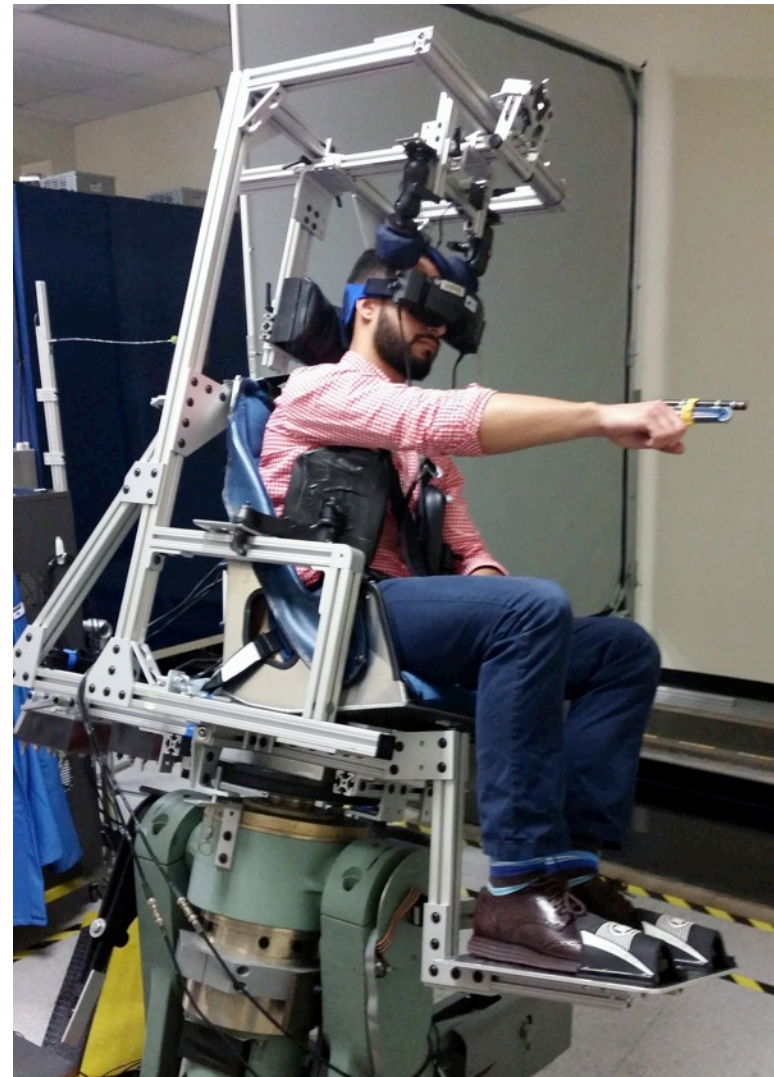
- The information that usually contributes to the **sense of body position** (static otolith input, proprioception) is altered in 0 g
- It is hypothesized that the subjective straight-ahead will **shift down** after adaptation to 0 g



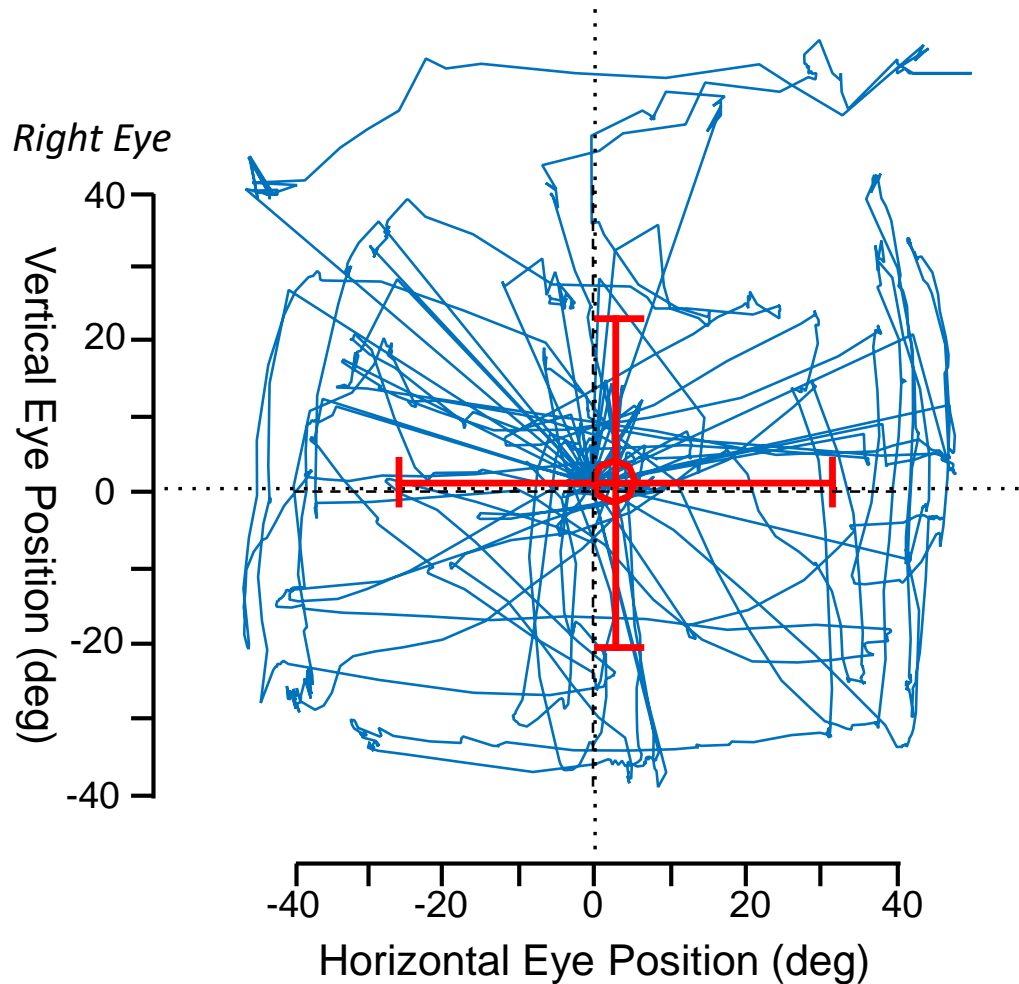
*Neutral Body Posture  
(NASA STD-3000)*

# Methods

- **Visual exploration** of space in darkness for 1 min
- **Directed eye saccades and arm movements** along head horizontal/vertical or along Earth horizontal/vertical during roll tilt
- **Gaze fixation** on near and far targets during pitch tilt
- Evaluate how a **vibrotactile feedback** of egocentric reference frame can be used to improve spatial orientation

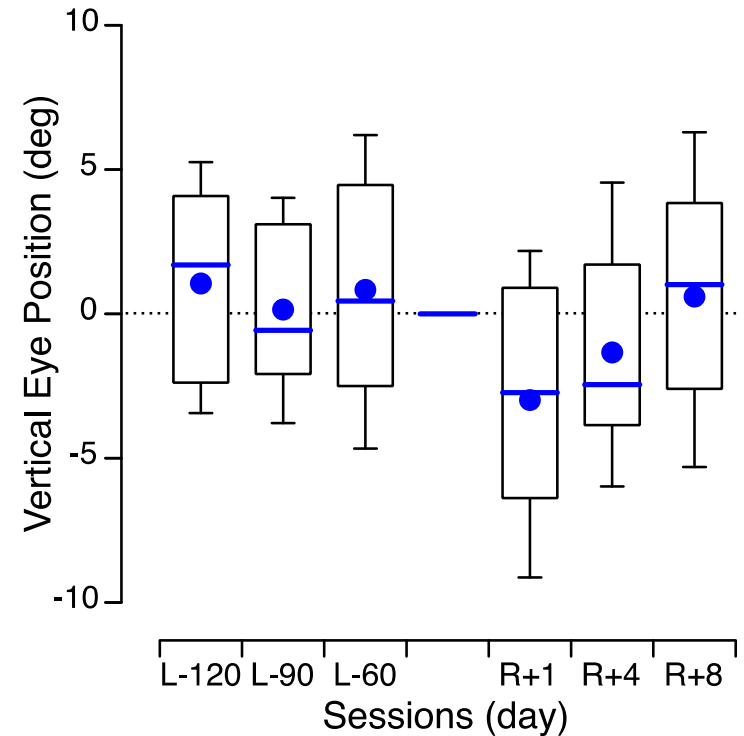
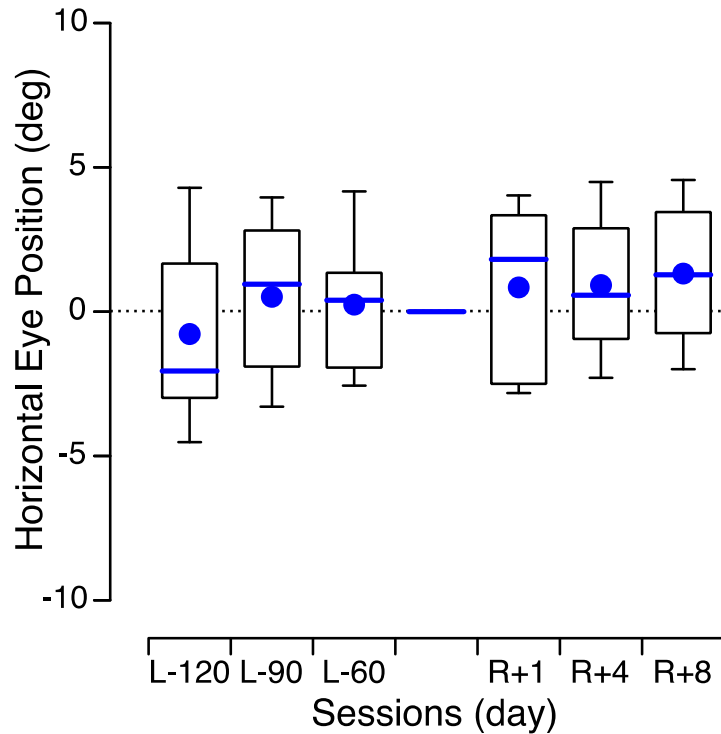
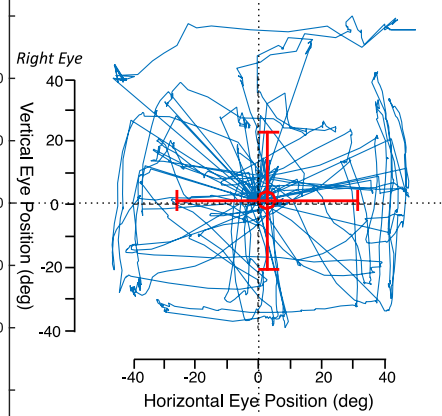


# Visual Exploration of Space



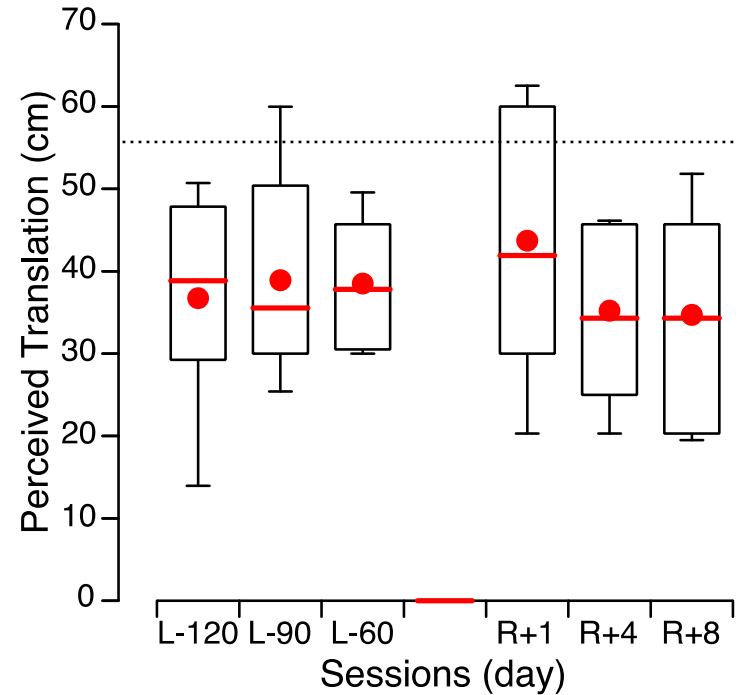
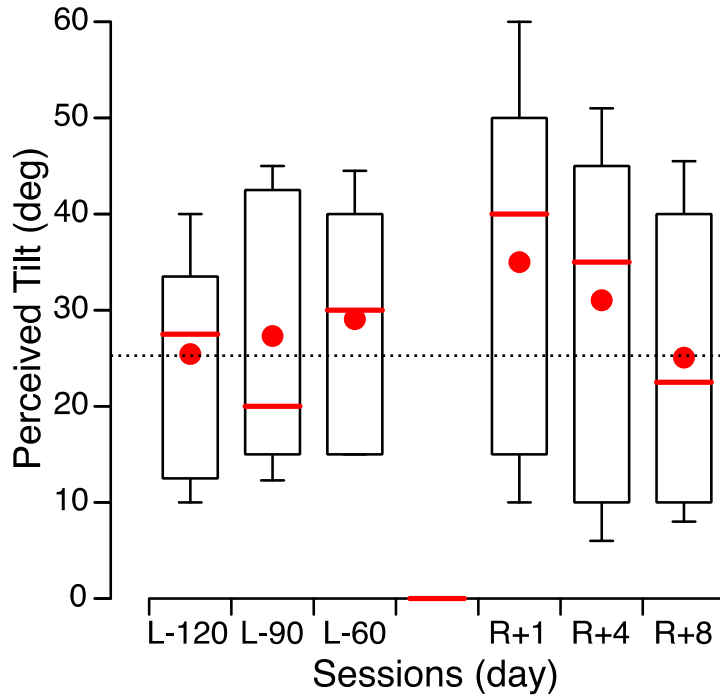
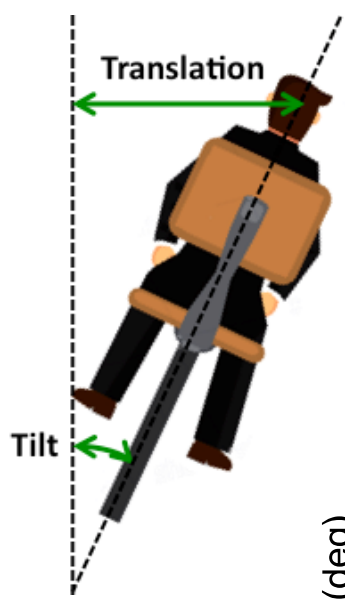
The average of all eye positions corresponds to the SSA

# Visual Exploration of Space



The average of vertical eye positions is deviated downwards after space flight

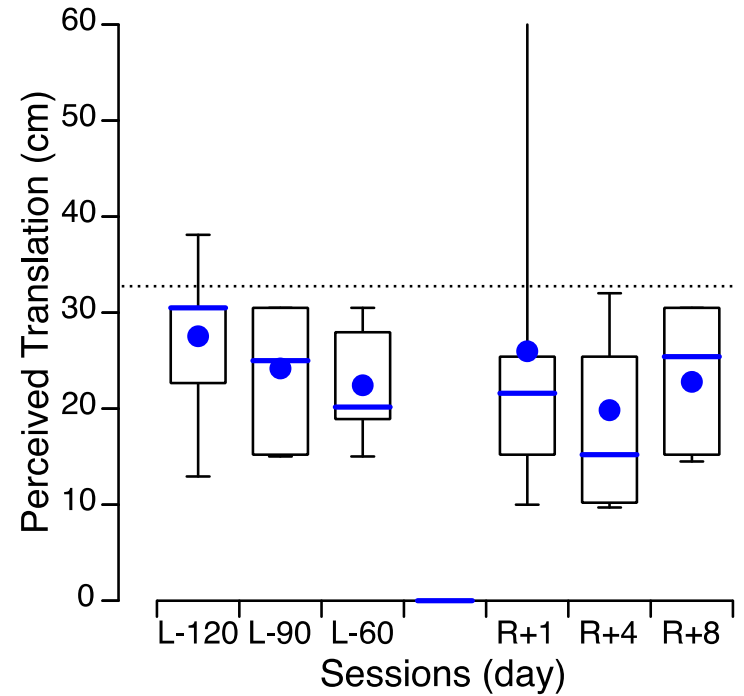
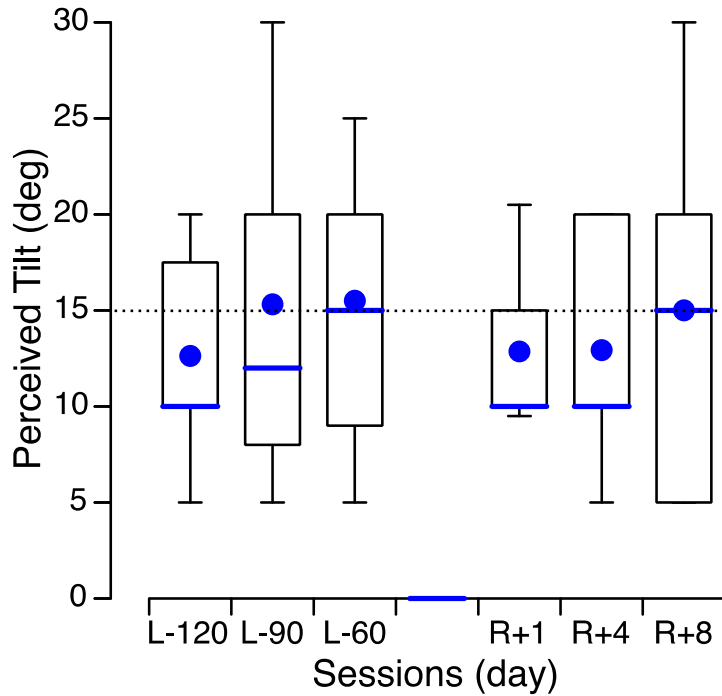
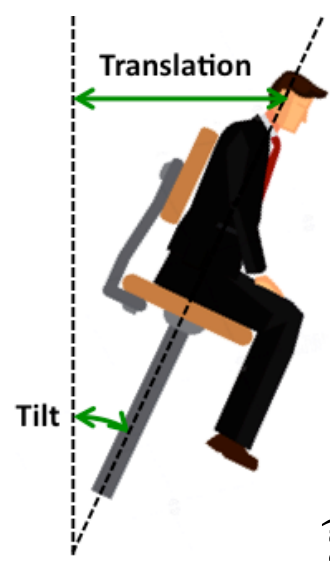
# Perception of Roll Tilt



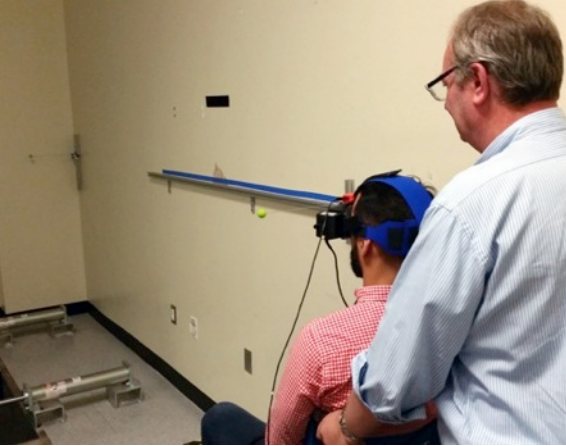
- Perceived roll tilt is overestimated on R+1
- Perceived translation is overestimated on R+1



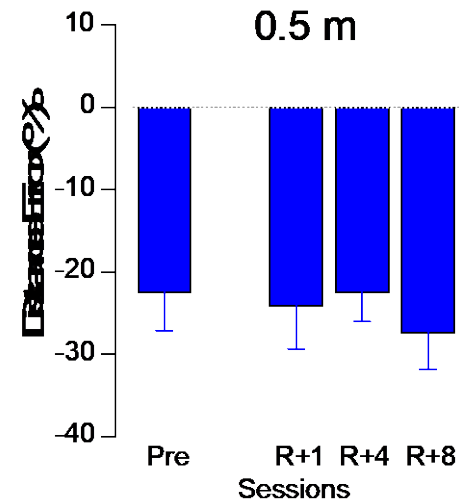
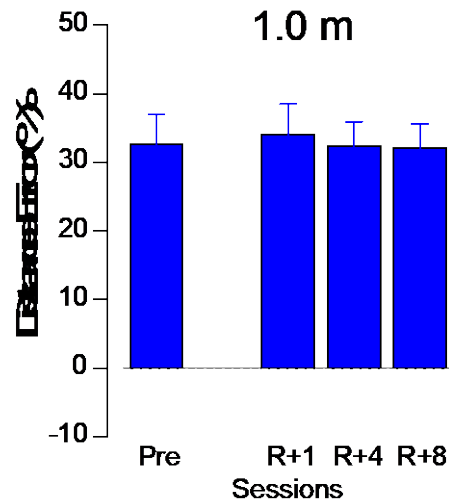
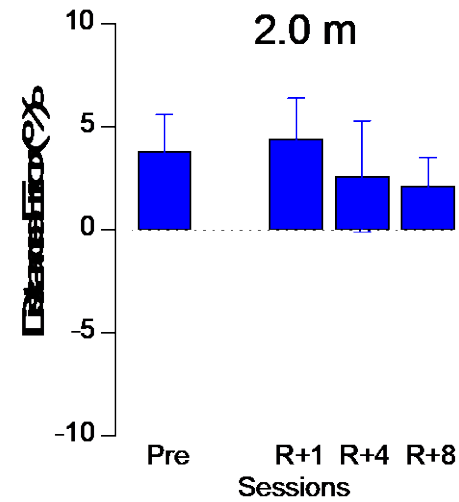
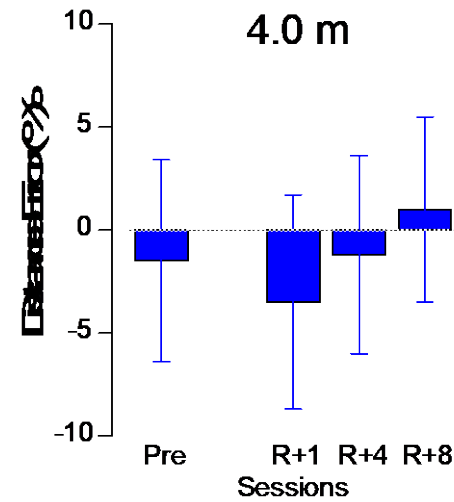
# Perception of Pitch Tilt



Perceived pitch tilt is not altered after space flight

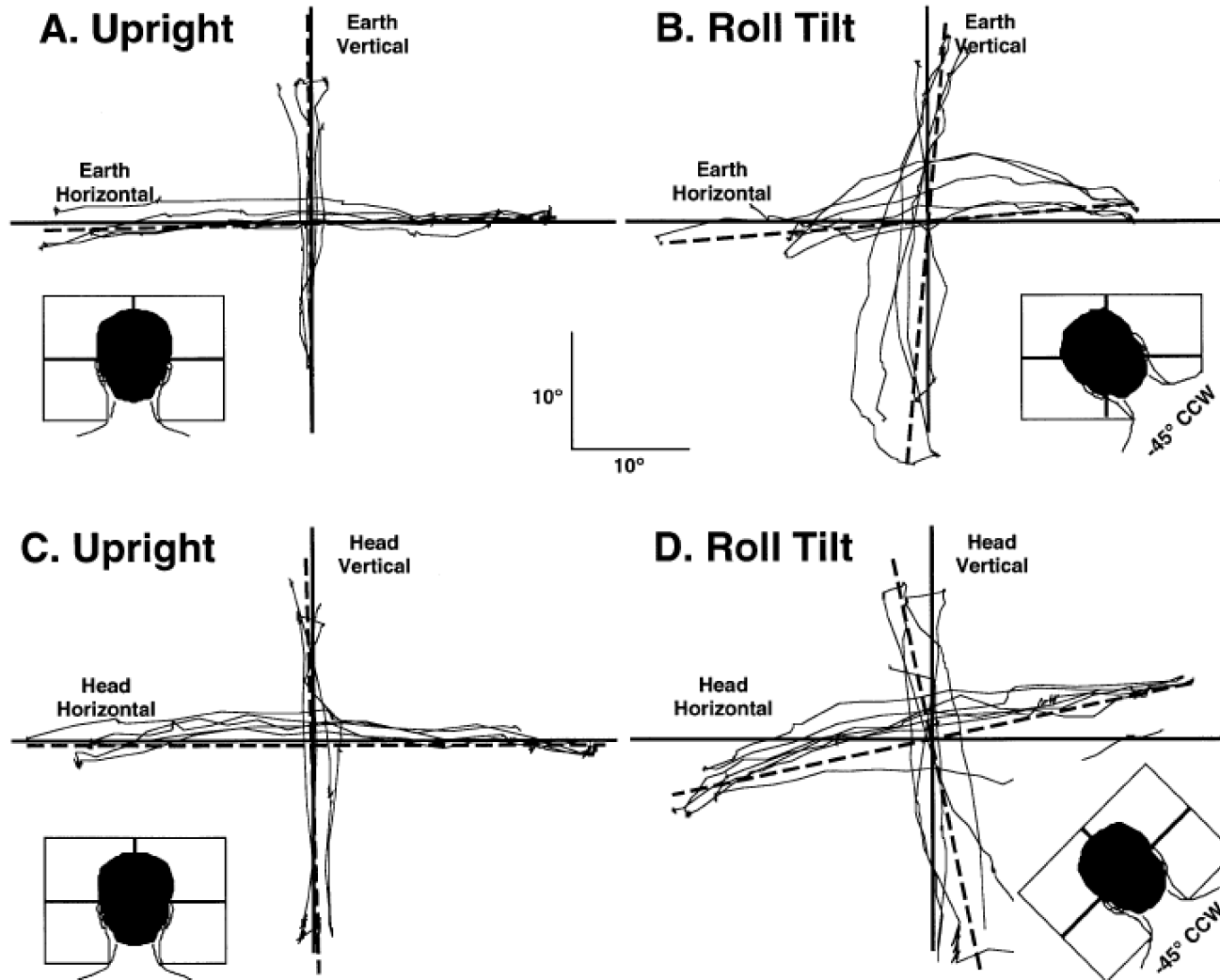


# Distance Perception

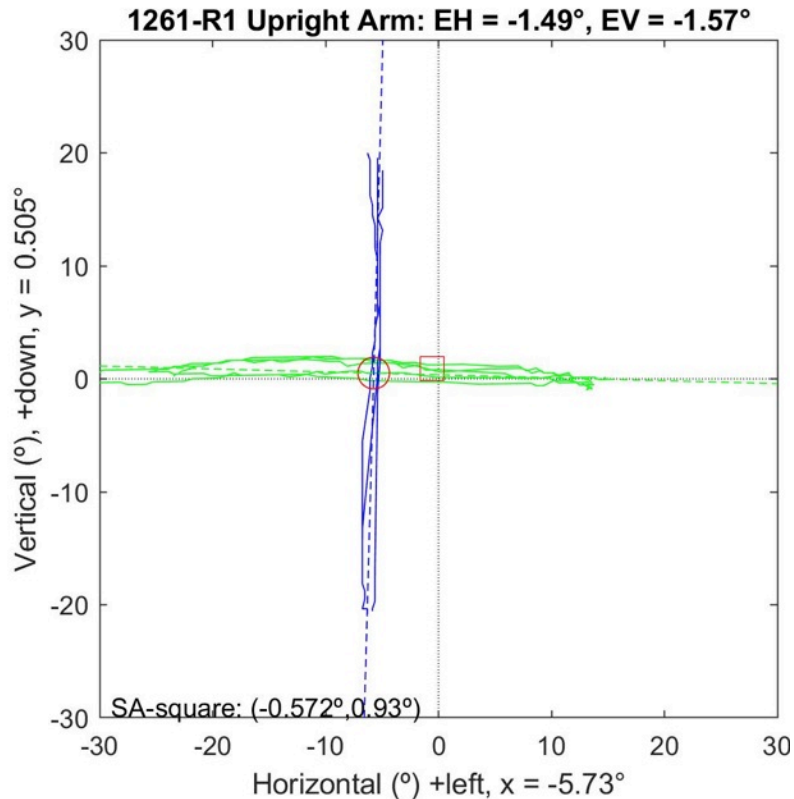
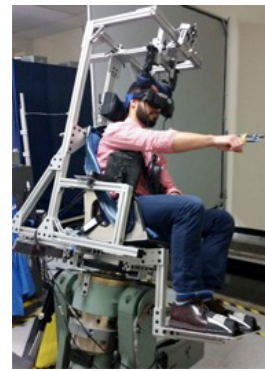


Perception of forward distances is not altered after space flight

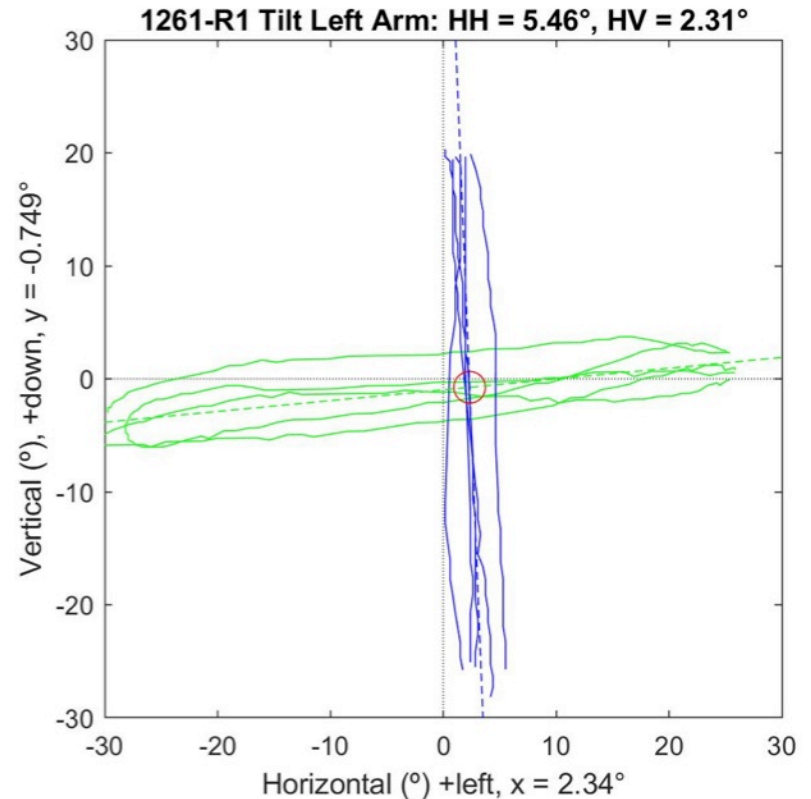
# Directed Saccades



# Directed Arm Saccades – R+1

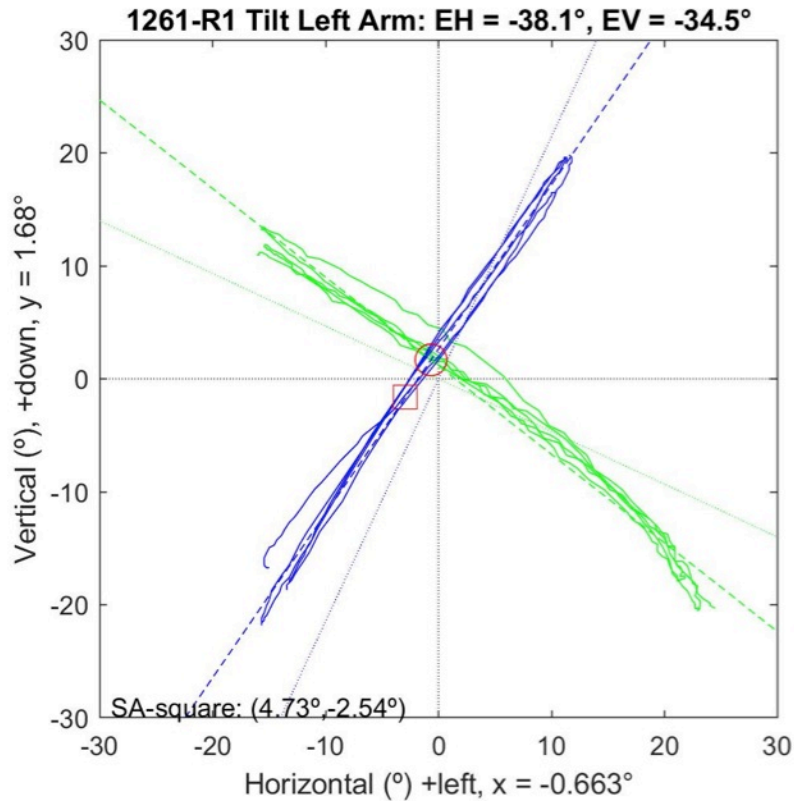
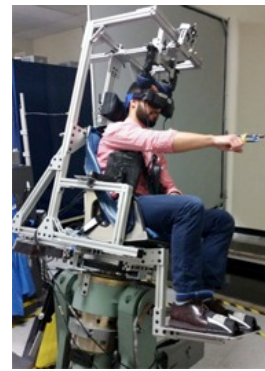


Subject A – Upright  
Saccades along Earth Hor/Ver

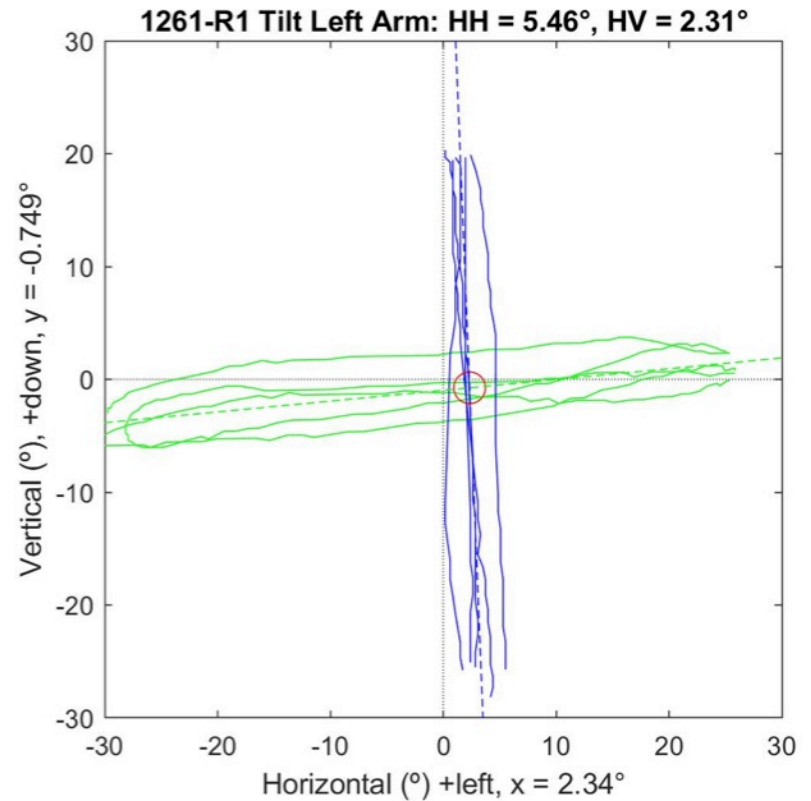


Subject A – Tilt to the Left  
Saccades along Head Hor/Ver

# Directed Arm Saccades – R+1

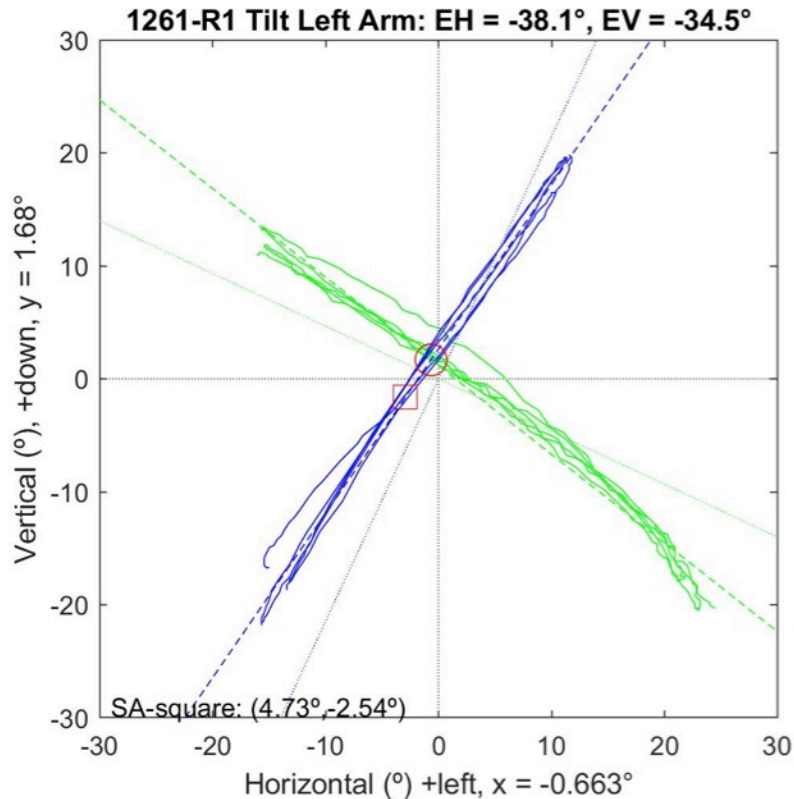
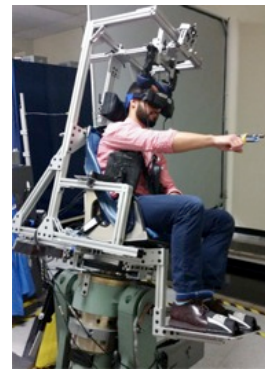


Subject A – Tilt to the Left  
Saccades along Earth Hor/Ver

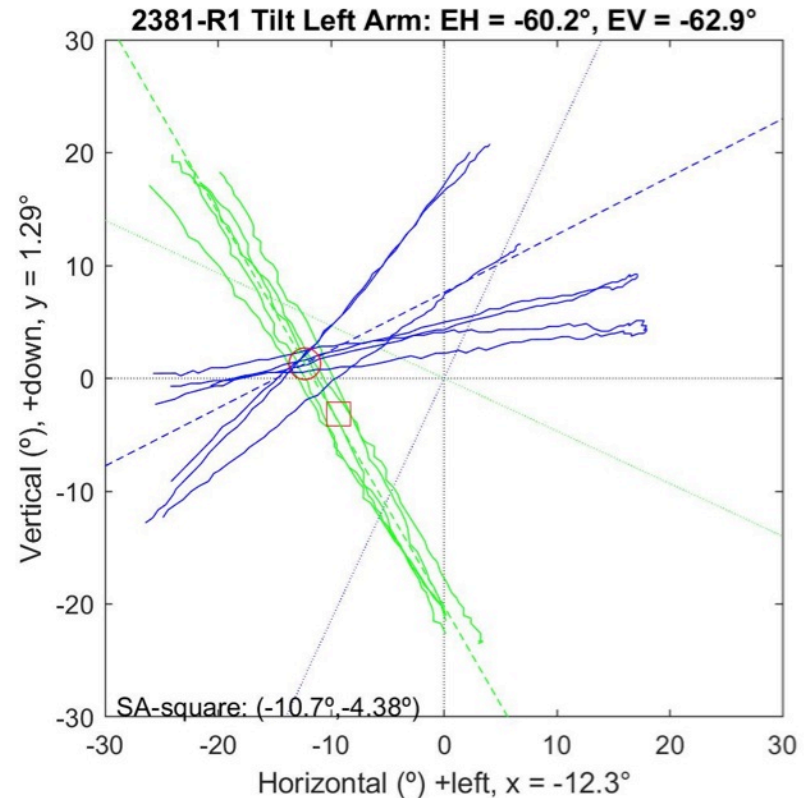


Subject A – Tilt to the Left  
Saccades along Head Hor/Ver

# Directed Arm Saccades – R+1



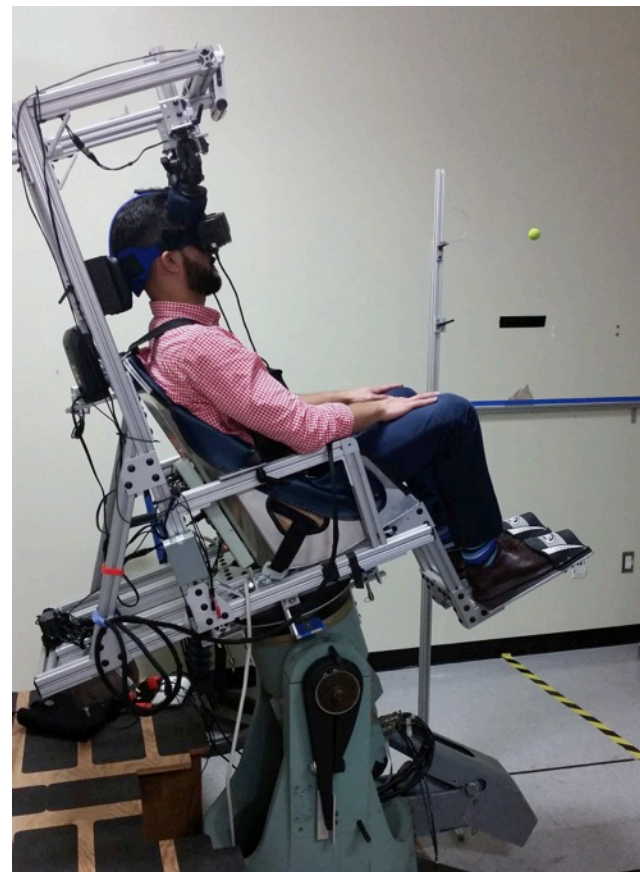
Subject A – Tilt to the Left  
Saccades along Earth Hor/Ver



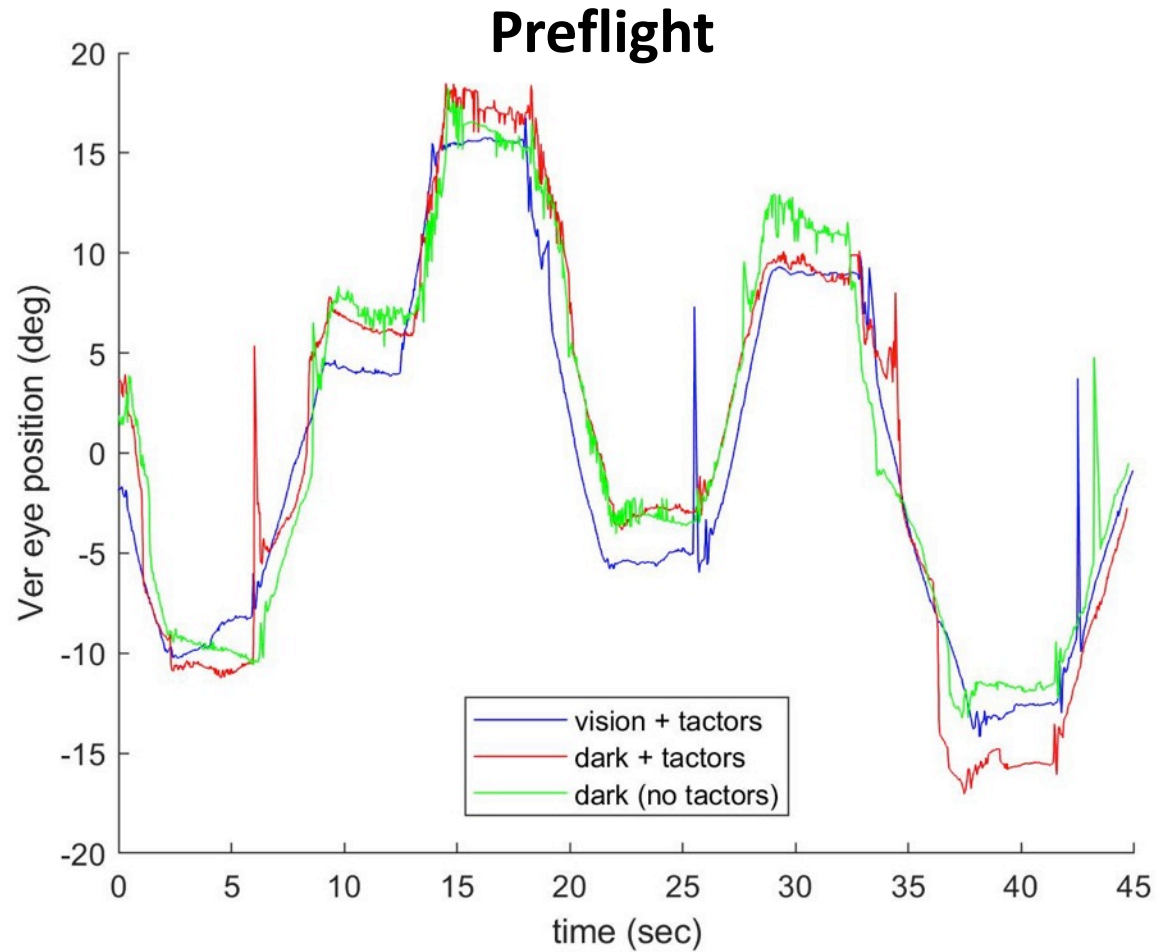
Subject B – Tilt to the Left  
Saccades along Earth Hor/Ver

# Vibrotactile Feedback

- **Gaze fixation** on near and far targets during pitch tilt
- Evaluate how a **vibrotactile feedback** of egocentric reference frame can be used to improve spatial orientation

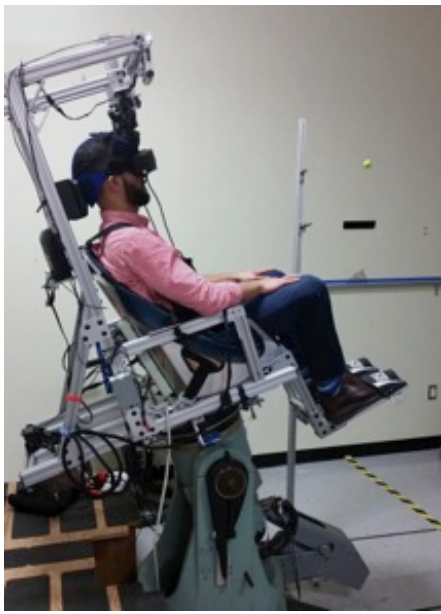


# Vibrotactile Feedback

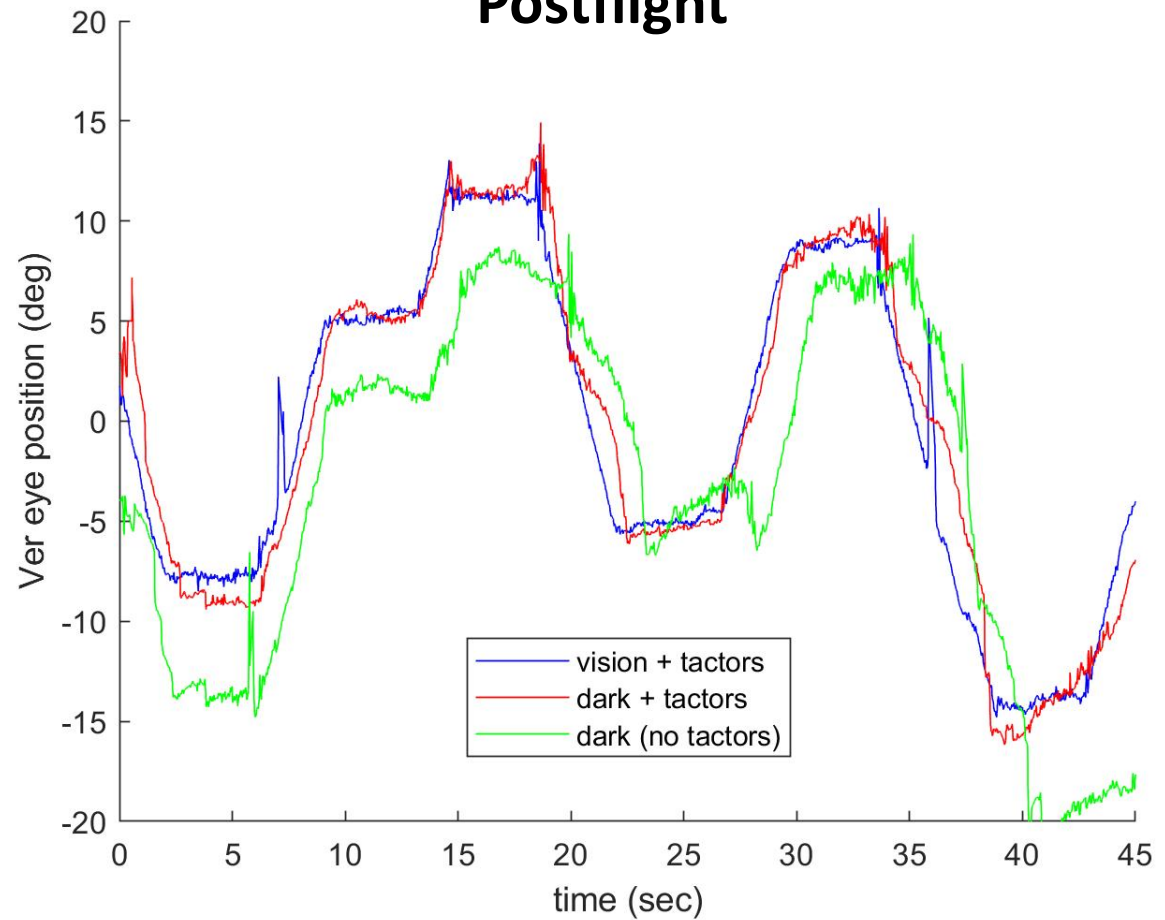




# Vibrotactile Feedback



## Postflight



# Conclusions

- After space flight, there is an overestimation of perceived roll tilt, but no change in the perception of pitch tilt
- Perceived amplitude of translation increases during roll tilt after space flight
- The subjective straight ahead shifts downward after space flight ( $\sim 5^\circ$ )
- Vibrotactile feedback partially compensates for this downward shift