Straight Ahead in Microgravity

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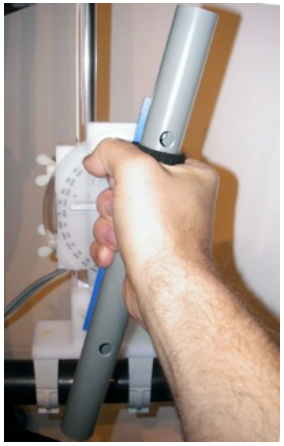
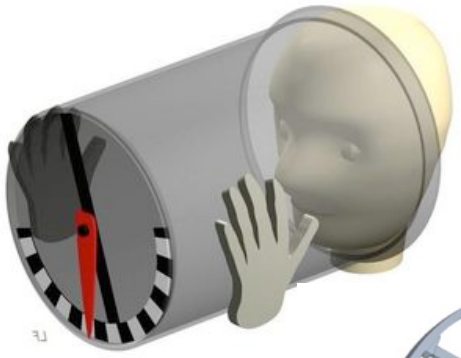
Spatial Orientation Perception Tests

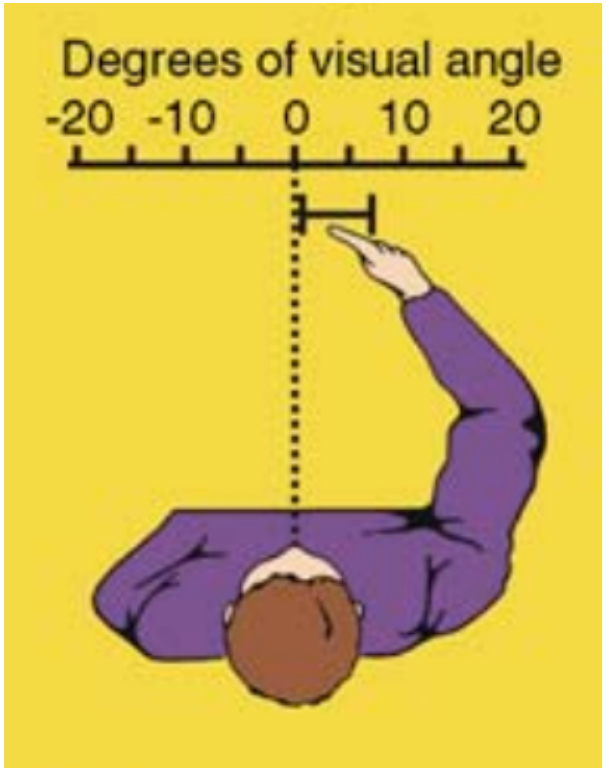
- **Subjective haptic vertical** – subjects with the eyes closed orient a bar in the Earth-vertical position
- **Subjective visual vertical** – subjects in darkness align a luminous bar along the perceived Earth-vertical
- **Subjective postural vertical** – subjects in darkness in a tilting apparatus 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)

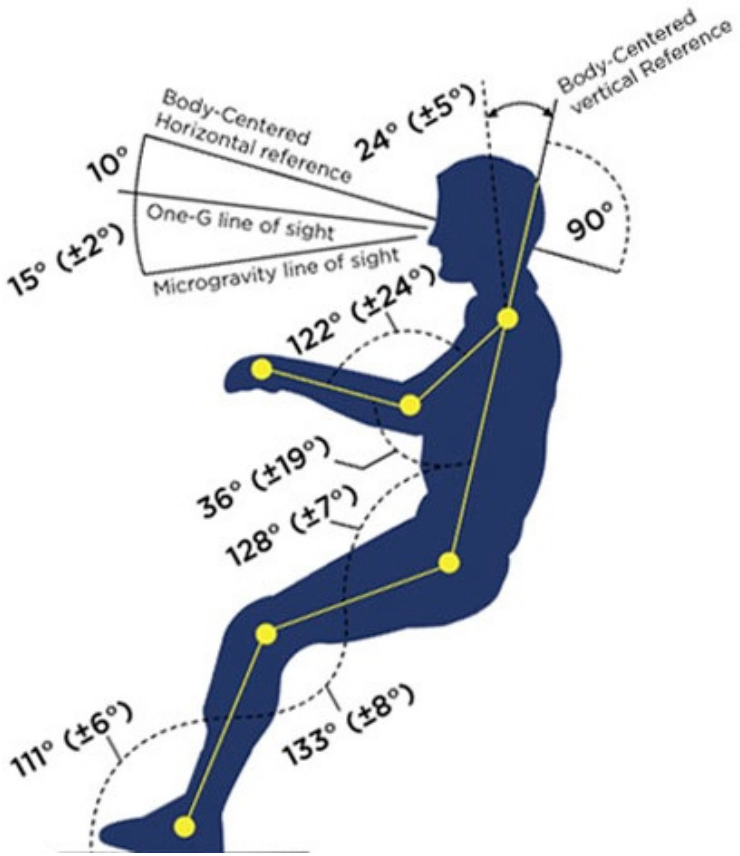
- Subjective straight-ahead (SSA) is the perceived projection of the **body midline** (head and trunk)
- **Egocentric** frame of reference
- When pointing with the arm at a body-centered line, the SSA is systematically **deviated** toward the arm by 4º ± 4º
- When pointing with the gaze, the SSA is **aligned**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



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

Hypothesis

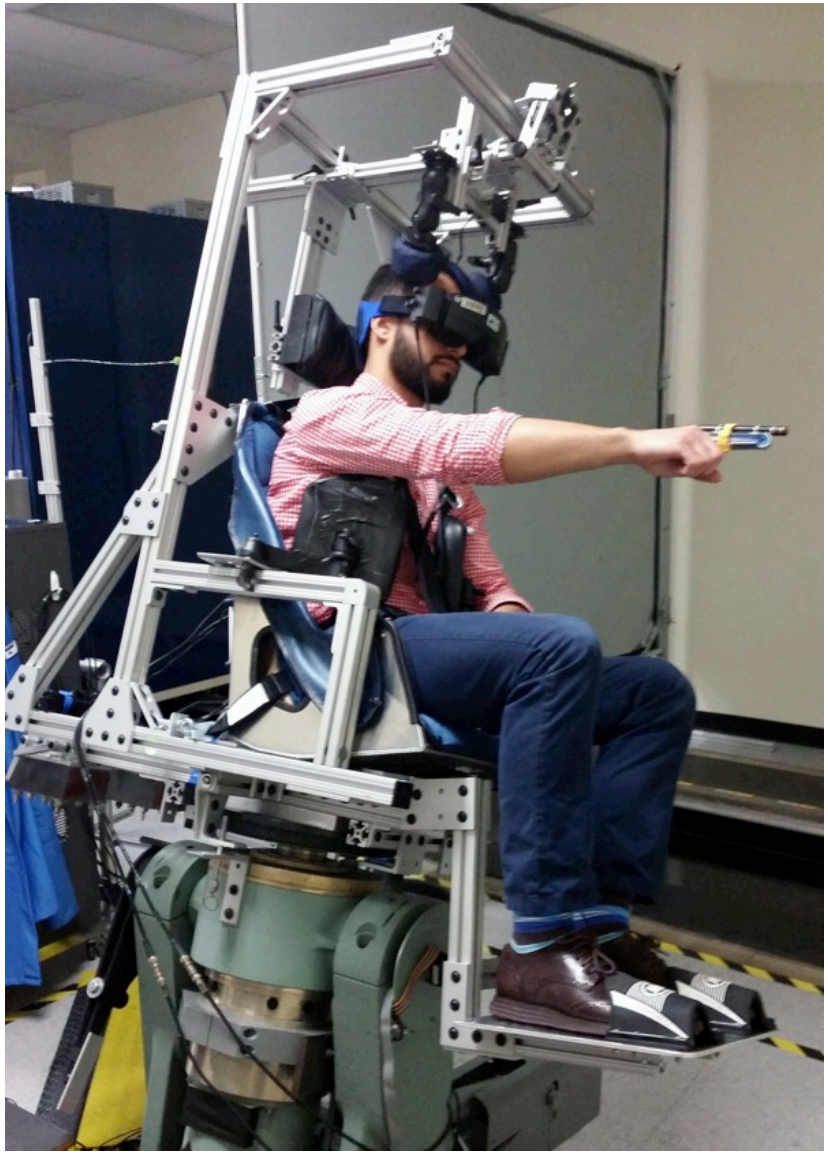
- The information that usually contributes to the **sense of body position** (static otolith input, proprioception) is altered in 0 g
- It is hypothesized that the subjective straight-ahead will **shift down** after adaptation to 0 g



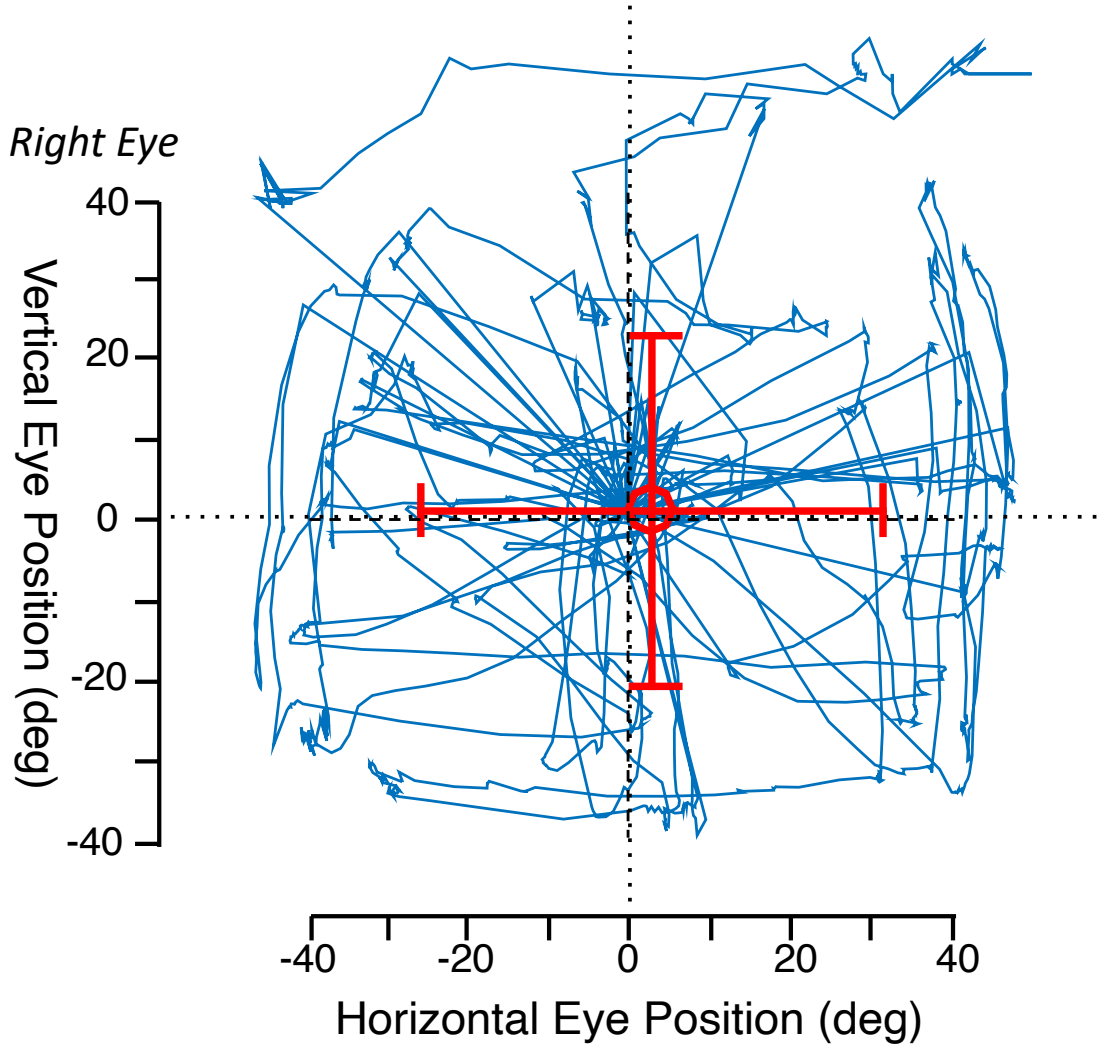
Neutral Body Posture (NASA STD-3000)

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

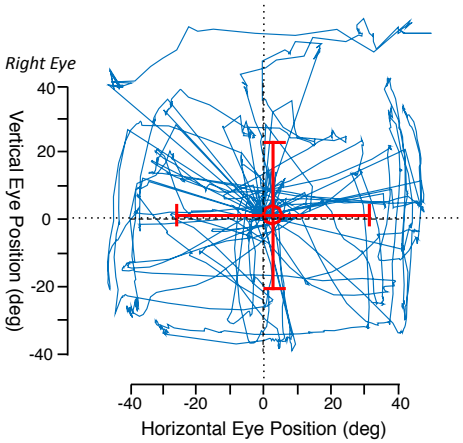


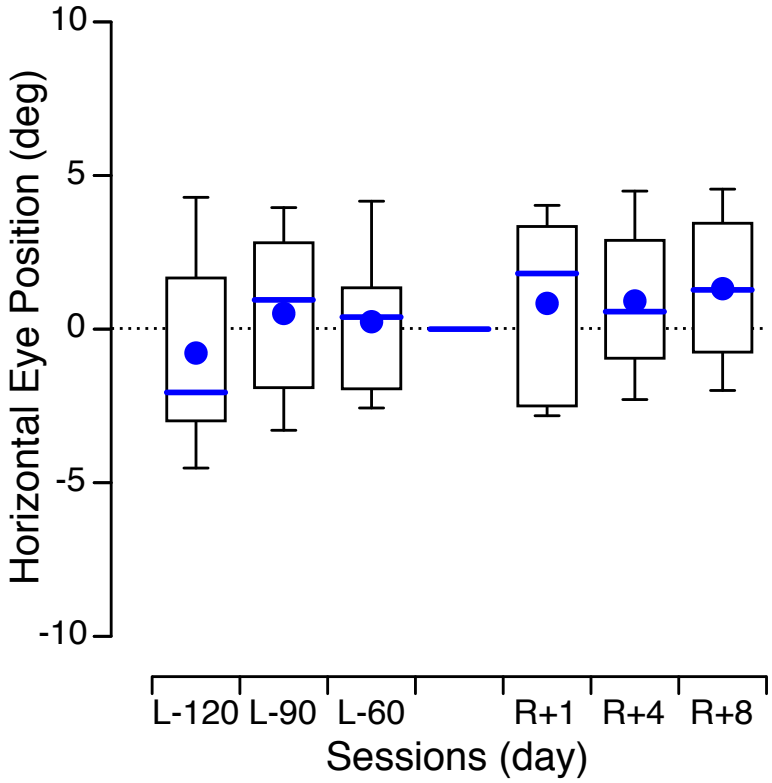
Visual Exploration of Space

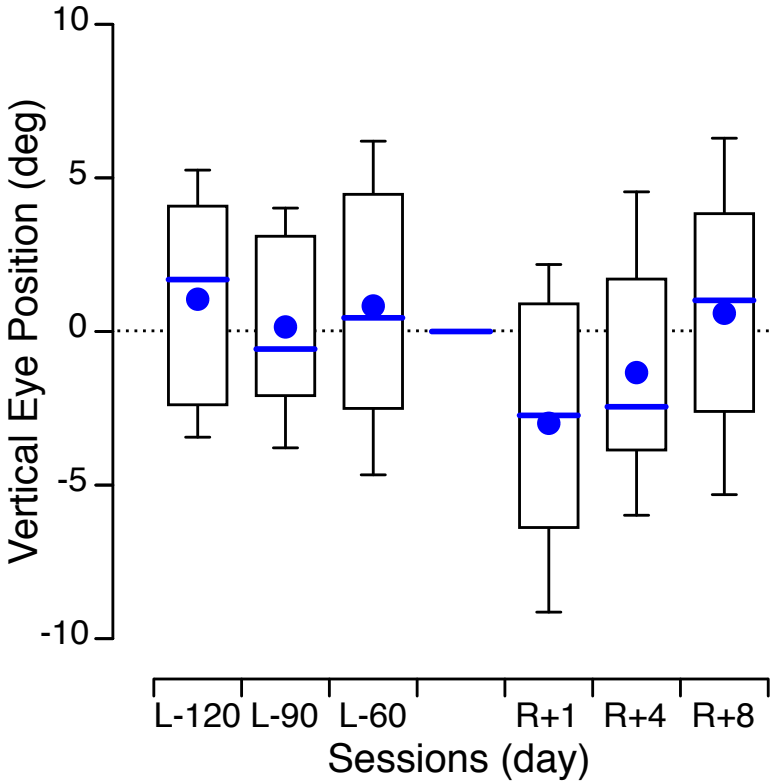


The average of all eye positions corresponds to the SSA

Visual Exploration of Space

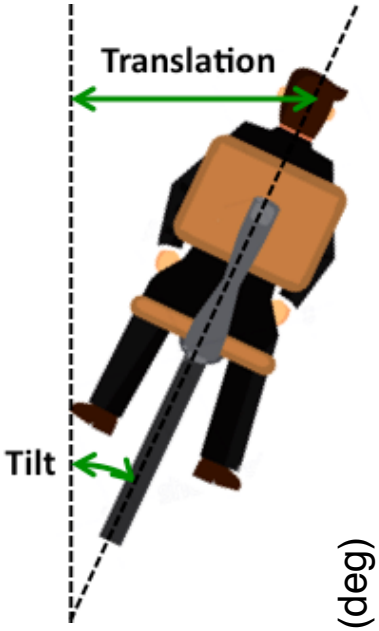


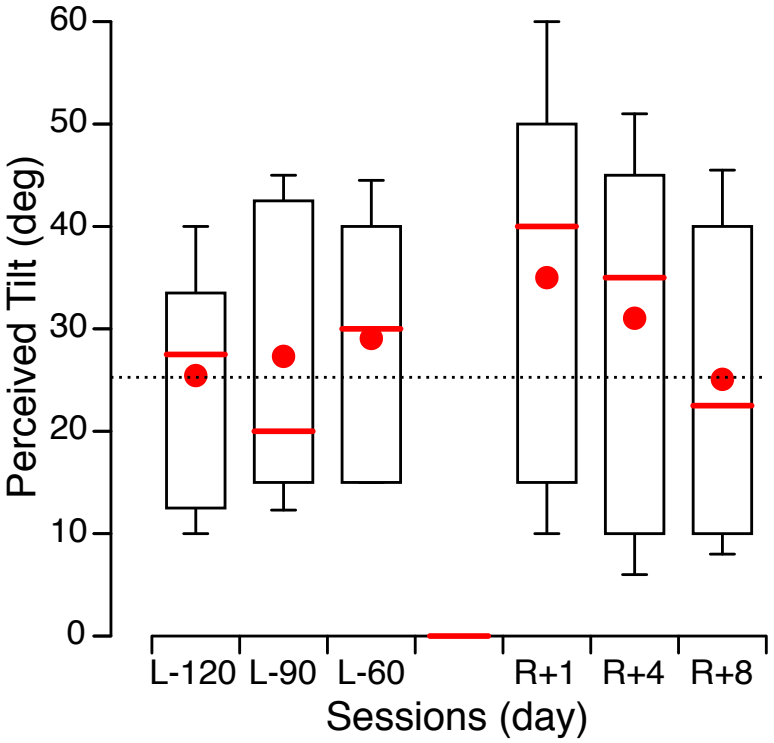


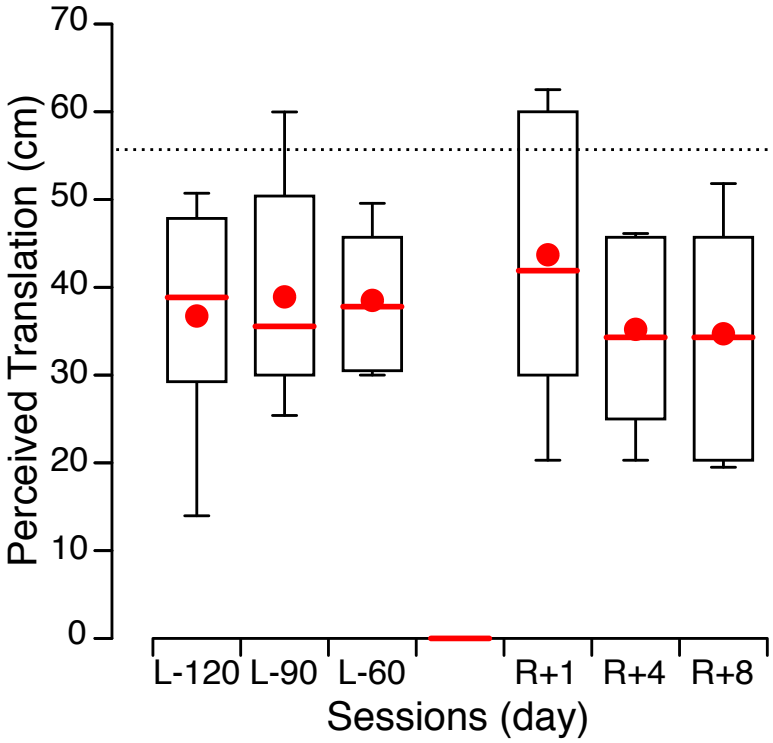


The average of vertical eye positions is deviated downwards after space flight

Perception of Roll Tilt

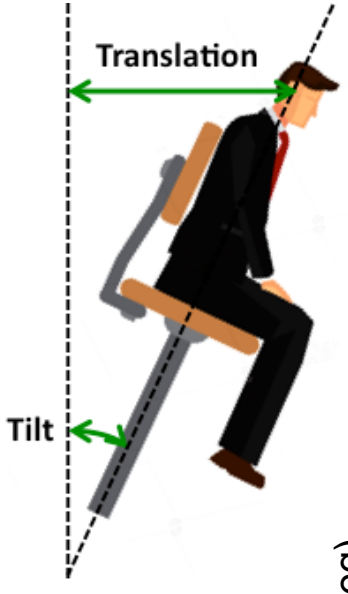


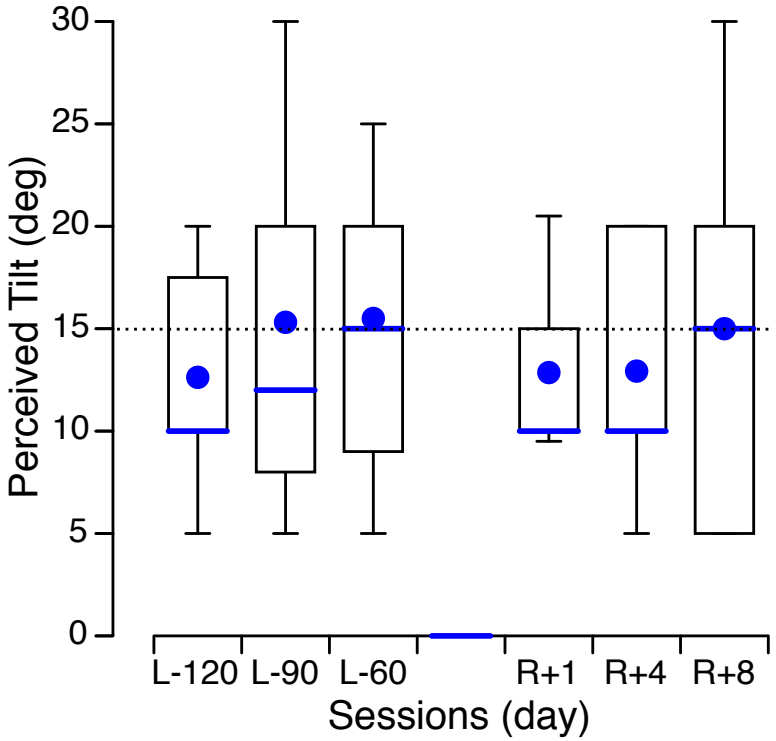


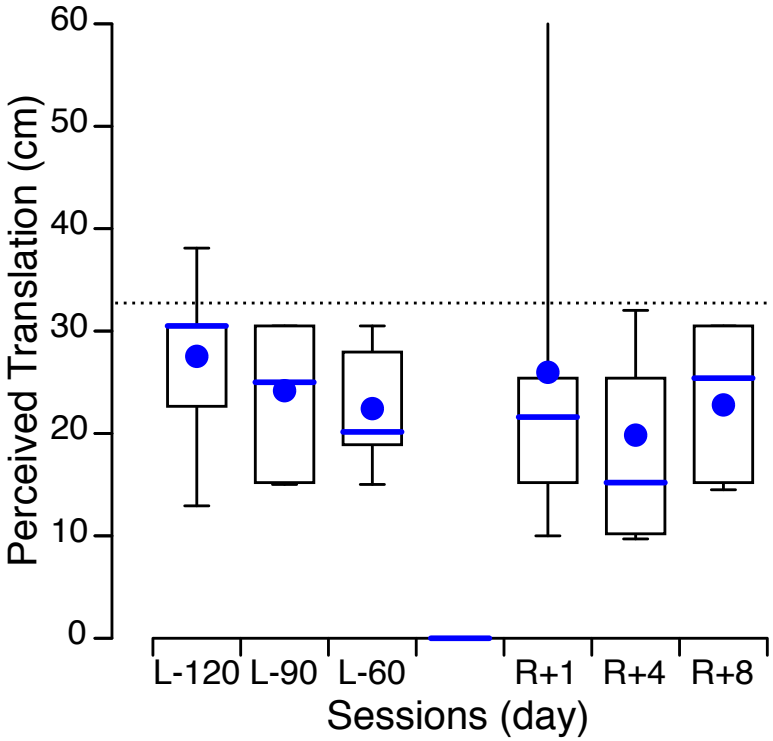


- Perceived roll tilt is overestimated on R+1
- Perceived translation is overestimated on R+1

Perception of Pitch Tilt

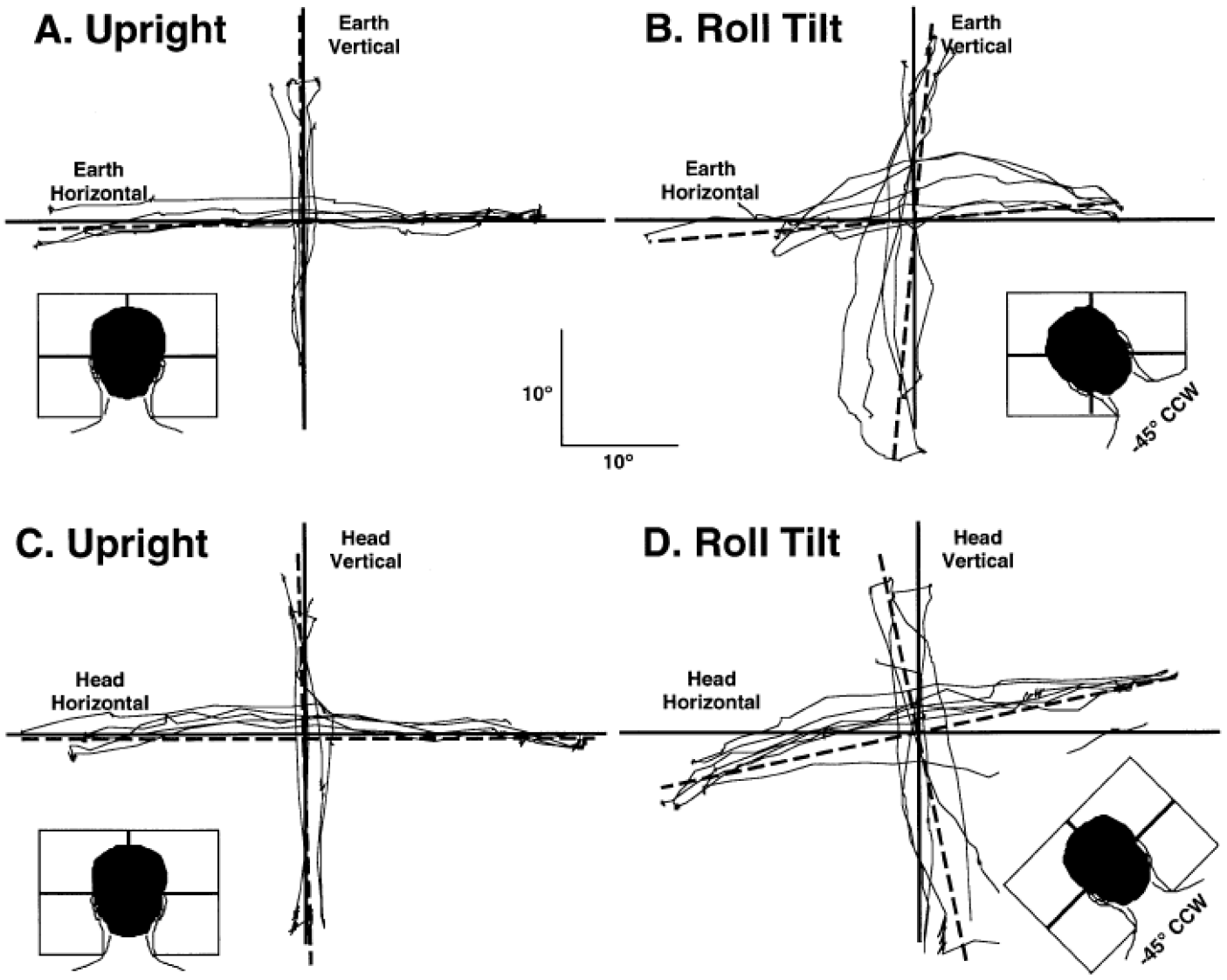






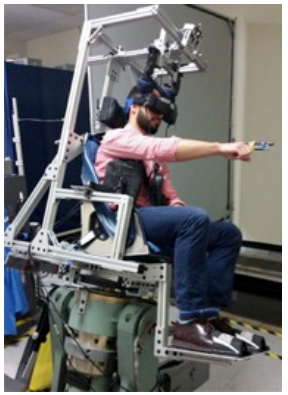
Perceived pitch tilt is not altered after space flight

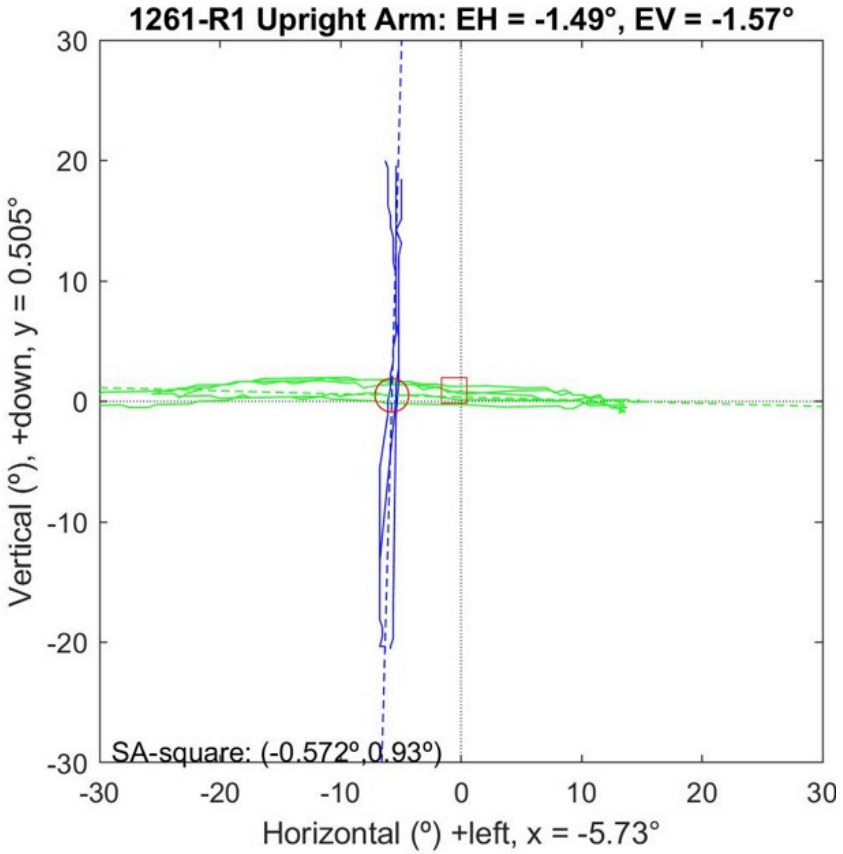
Directed Saccades



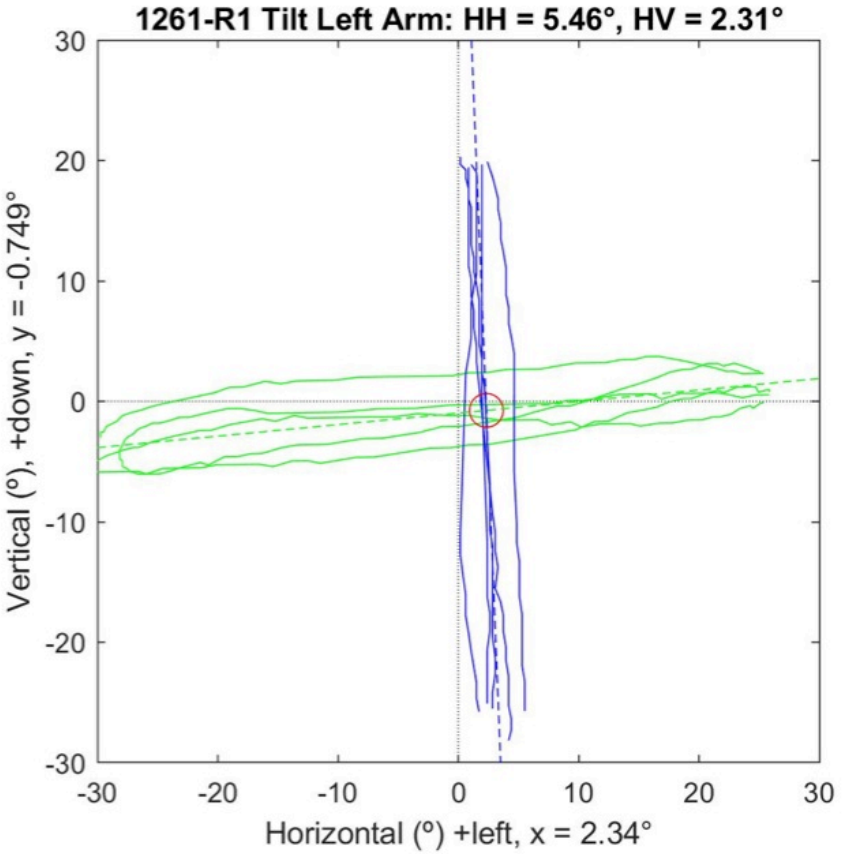
Wood et al. (1998) Exp Brain Res 121: 51-58

Directed Arm Saccades – R+1



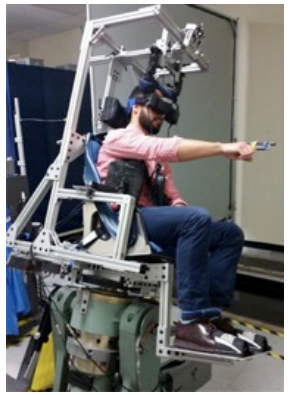


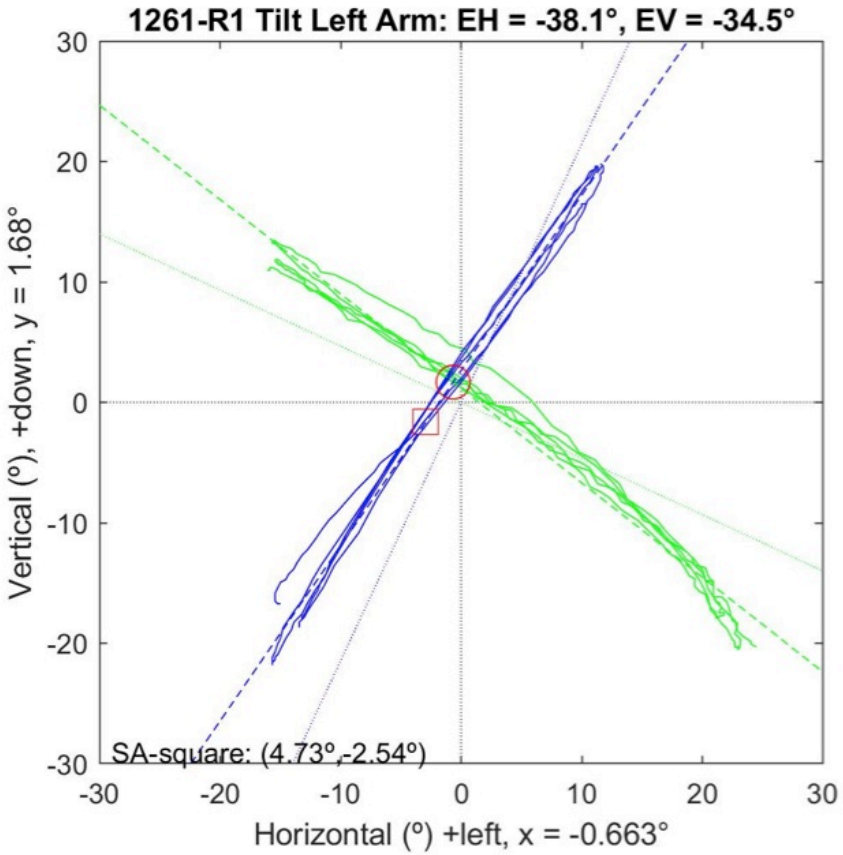
Subject A – Upright
Saccades along Earth Hor/Ver



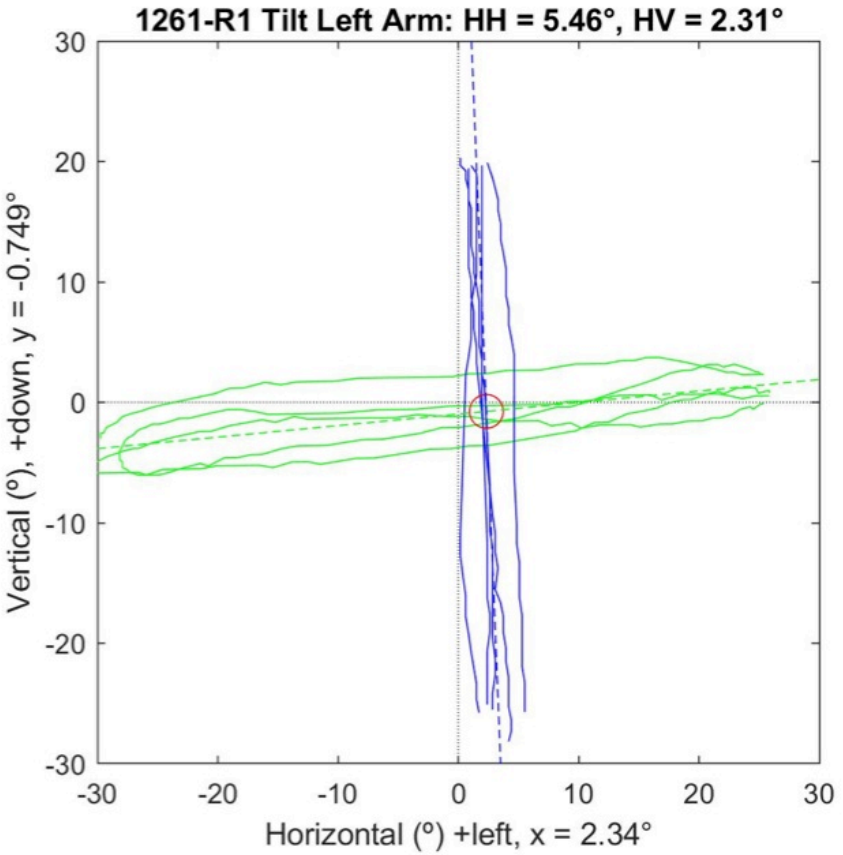
Subject A – Tilt to the Left
Saccades along Head Hor/Ver

Directed Arm Saccades – R+1



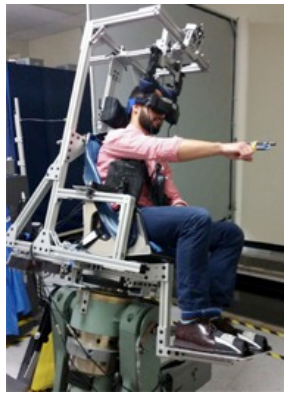


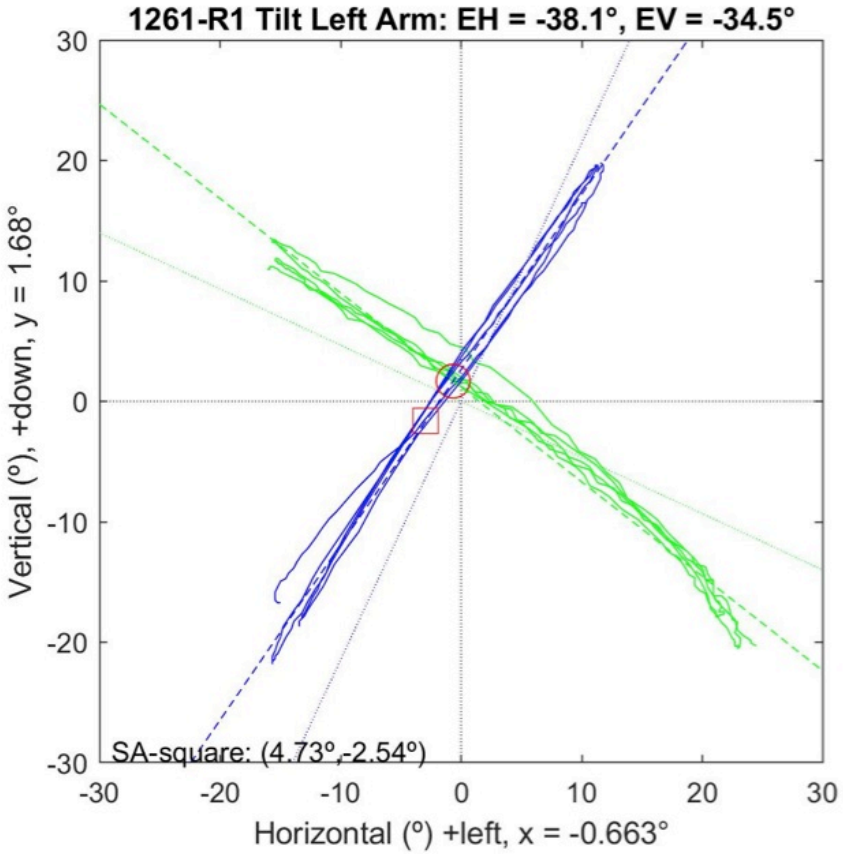
Subject A – Tilt to the Left
Saccades along Earth Hor/Ver



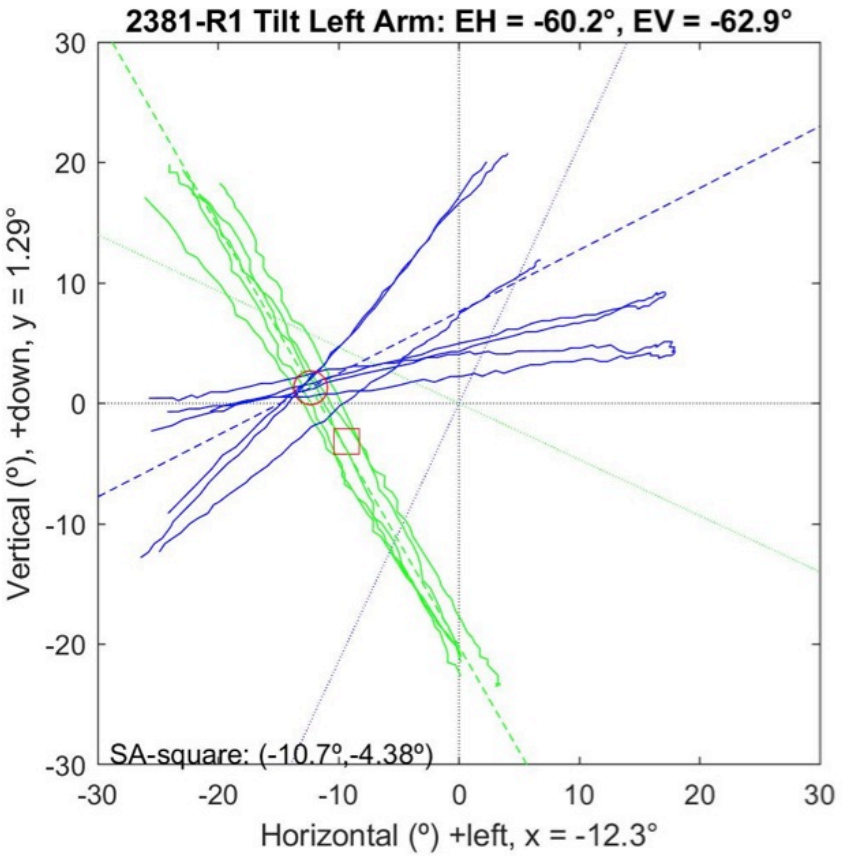
Subject A – Tilt to the Left
Saccades along Head Hor/Ver

Directed Arm Saccades – R+1





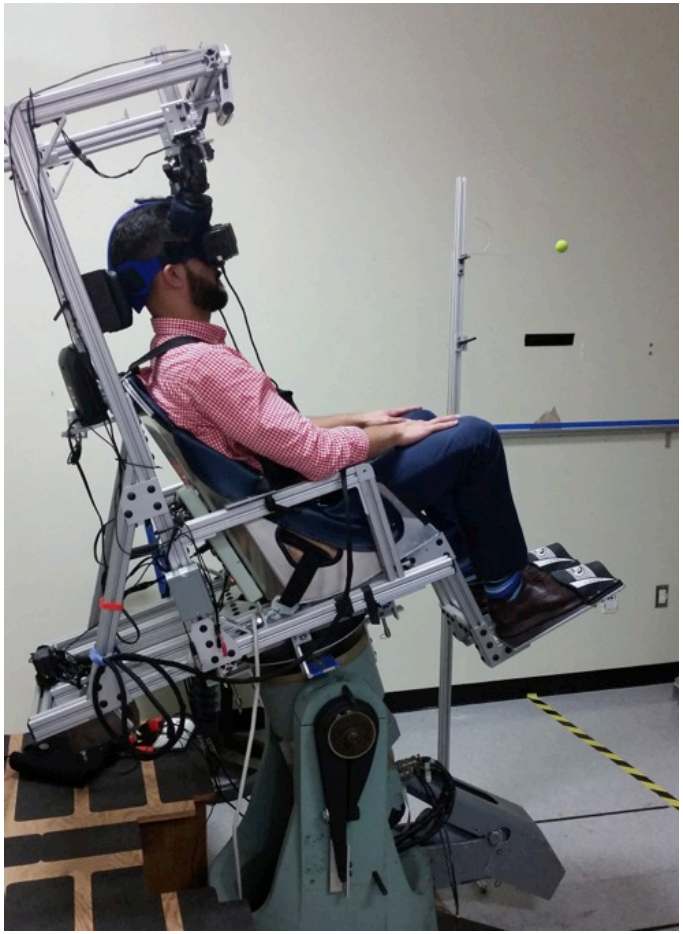
Subject A – Tilt to the Left
Saccades along Earth Hor/Ver

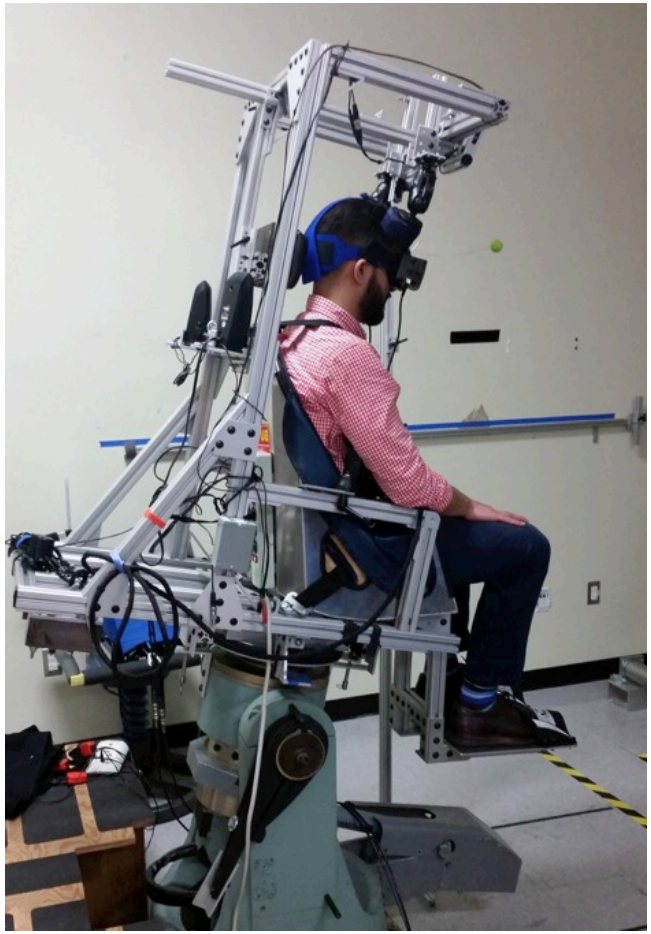


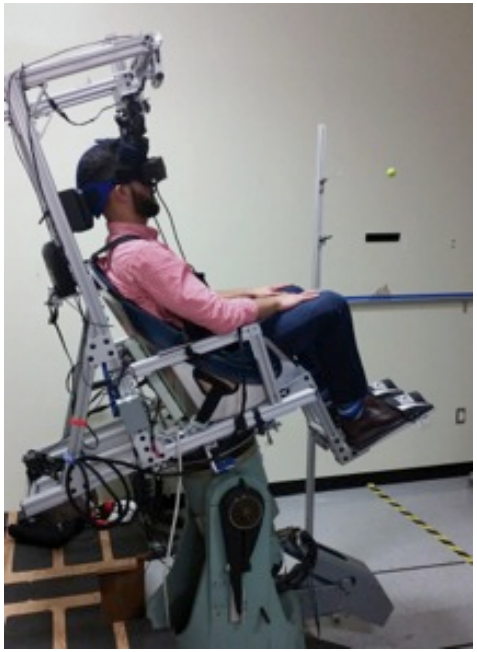
Subject B – Tilt to the Left
Saccades along Earth Hor/Ver

Vibrotactile Feedback

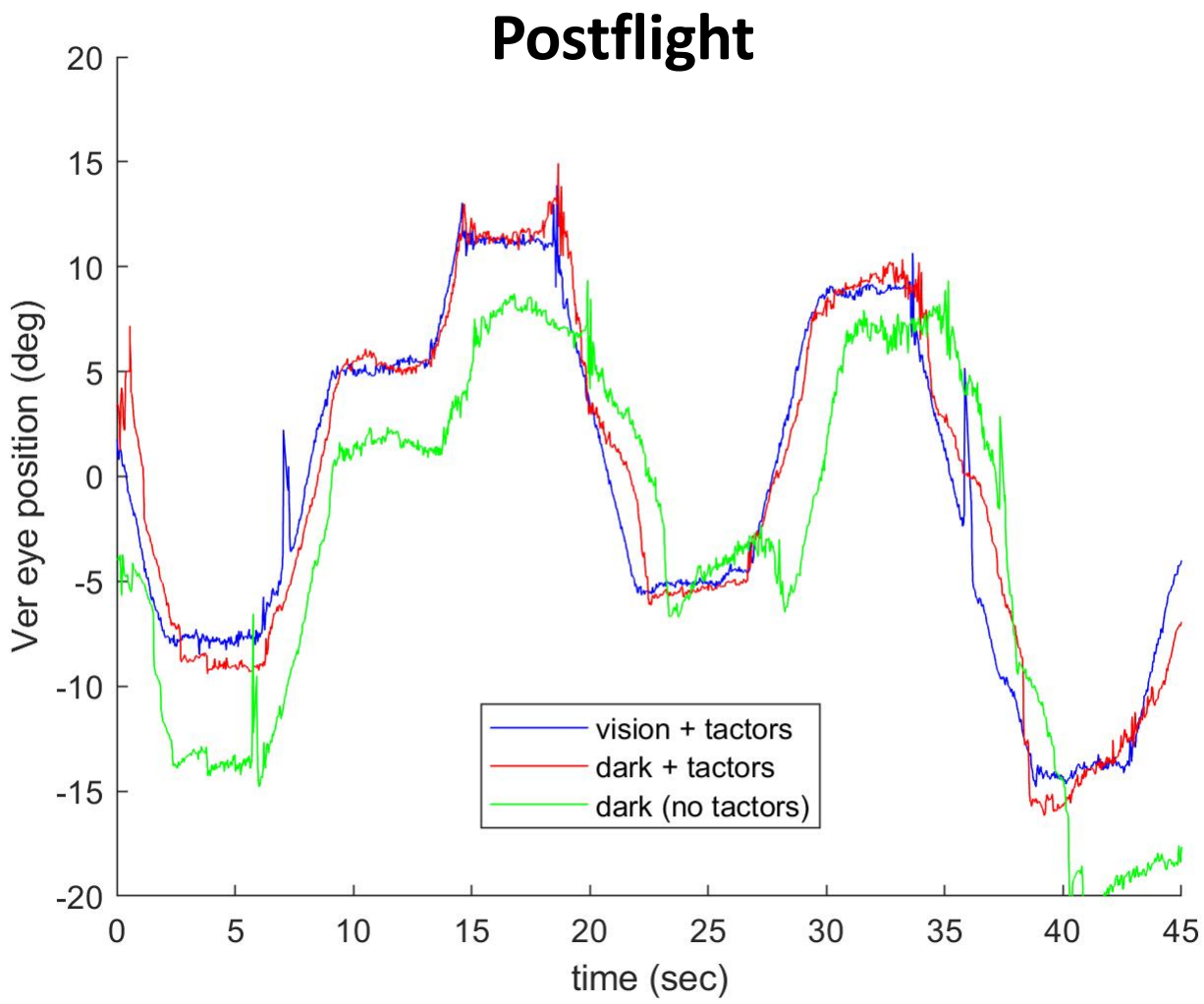
- **Gaze fixation** on near and far targets during pitch tilt
- Evaluate how a **vibrotactile feedback** of egocentric reference frame can be used to improve spatial orientation







Vibrotactile Feedback



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 (~ 5º)
- Vibrotactile feedback partially compensates for this downward shift