

# Cognitive Performance Associations with Vestibular Dysfunction in Spaceflight and the Potential for Efficient Rehabilitation

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## BACKGROUND

- Human spaceflight involves simultaneous response to multiple stressors
- Astronauts are often subjects of biomedical studies, which are rarely examined for synergies
- Cognition is a battery of 10 tests spanning diverse cognitive functions
- Ocular Alignment (OA) is a visual perceptual measure of vertical and torsional alignment of the eyes
- Inspiration4 (I4) was first all-civilian trip to space

## STUDY OBJECTIVE

- Identify correlations between Cognition and OA metrics to better understand spaceflight's impact on functioning
- Determine relationship between vestibular and cognitive adaptations

## METHODS

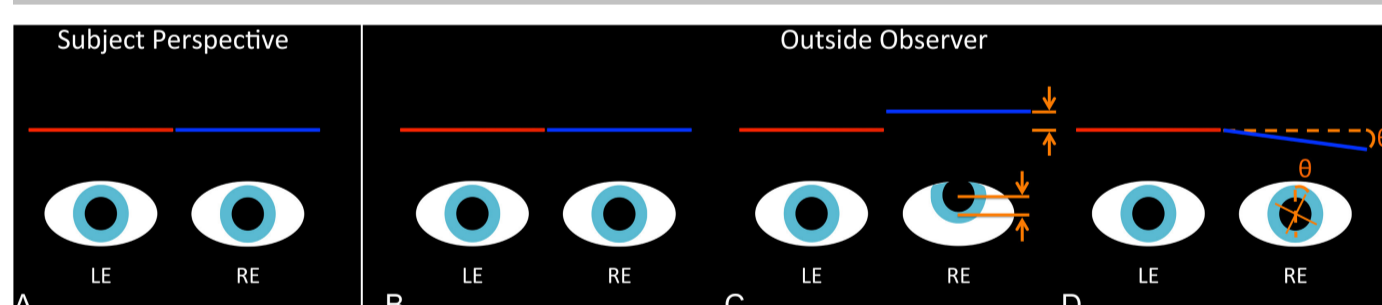


Figure 1: In OA, the subject repositions the blue line until it appears in line with the red. Vertical and torsional eye alignment is inferred from relative positioning of lines at end of each trial. Each session involves 11 trials in each axis. (from Schubert et al, 2017)

- Cognition and OA tests assessed on 4 civilian astronauts with 2 sessions before and 2 after I4 mission
- Cognition administered as 10 separate tests each session; returns a separate z-score for each test
- Subjects consist of 2M, 2F; age range from 29-51
- Correlation coefficients between Cognition and OA scores and score changes from flight
- Mixed-effect analyses performed between scores, response times, score changes from flight, and onset of space motion sickness (SMS)
- Overlaps in Cognition and OA cross-validated

## RESULTS

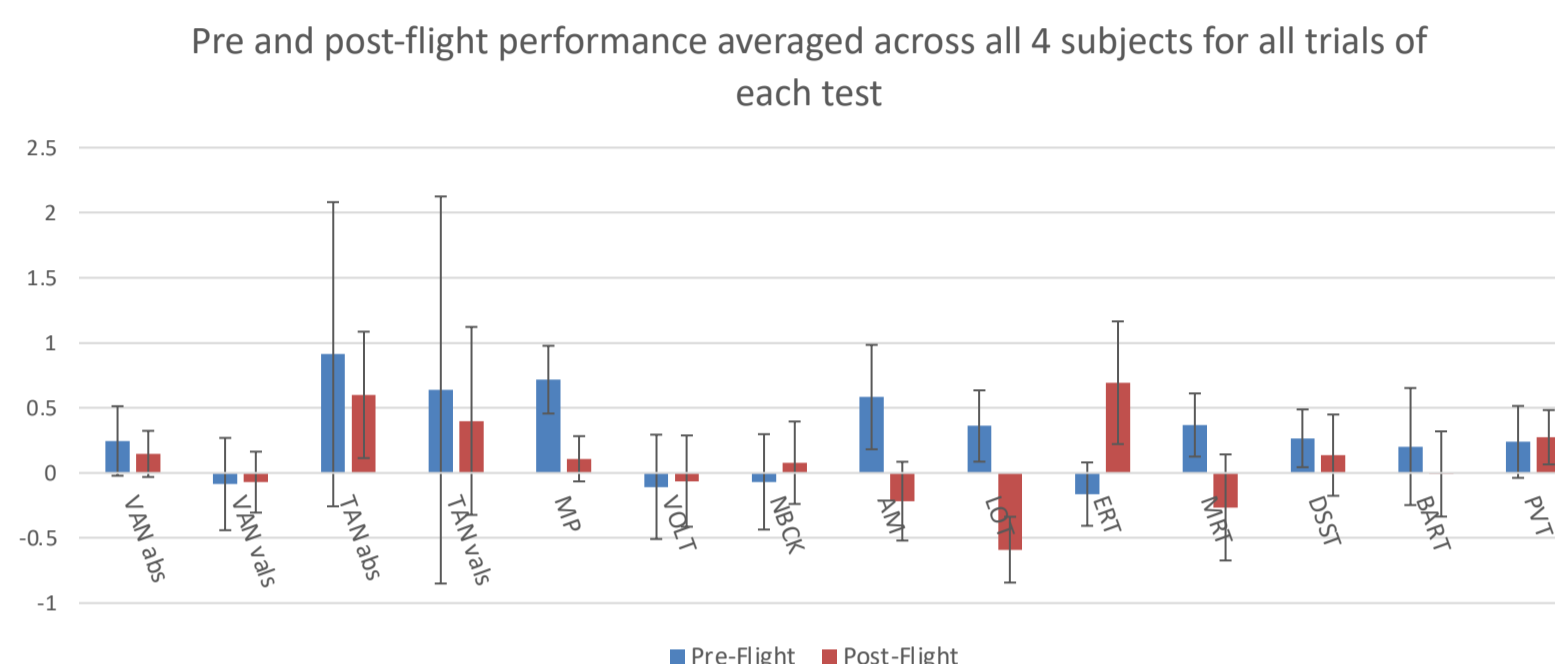


Figure 2: MP, AM, LOT, ERT, MRT show potential pre-/post-flight response time differences

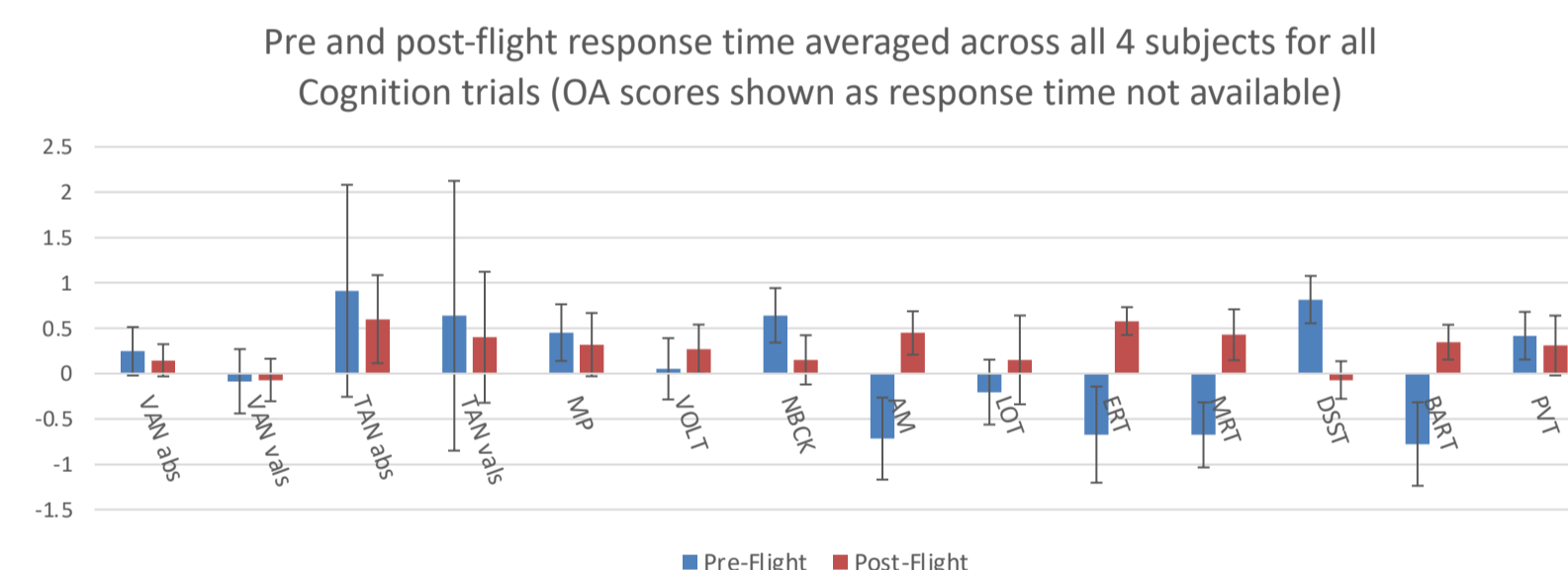


Figure 3: AM, ERT, MRT, DSST, BART show potential pre-/post-flight response time differences

	MP	VOLT	NBCK	AM	LOT	ERT	MRT	DSST	BART	PVT
<b>VAN value</b>	0.744	-0.260	0.165	0.646	-0.635	0.408	0.610	0.237	-0.425	-0.100
<b>TAN value</b>	0.673	-0.173	0.103	0.578	-0.666	0.348	0.530	0.223	-0.367	-0.137

Table 1: Correlations between VANTAN score changes and Cognition score changes from pre- to post-flight

Test acronyms: VAN: Vertical Alignment Nulling; TAN: Torsional Alignment Nulling; MP: Motor Praxis; VOLT: Visual Object Learning; NBCK: Fractal 2-back; AM: Abstract Matching; LOT: Line Orientation; ERT: Emotion Recognition; MRT: Matrix Reasoning; DSST: Digital Symbol Substitution; BART: Balloon Analog Risk; PVT: Psychomotor Vigilance

## Mixed-Effect Analyses

- While spaceflight reduced (improved) torsional asymmetry by 0.31 degree ( $p=0.017$ ), it decreased performance in the Cognition test of Line Orientation (0.95 StD decline,  $p=0.014$ )
- Each additional degree of vertical asymmetry from pre- to post-flight associated with a decrease in time to complete individual Cognition tests by 0.92 StD ( $p=0.056$ )
- Each additional degree of vertical asymmetry associated with an increase in score across all Cognition tests of 1.15 StD ( $p=0.030$ ), an effect driven by those with SMS

## CONCLUSIONS

- Change in vertical otolith asymmetry associated with improved Cognition performance
- Supports hypothesis that larger changes in otolith asymmetry reflect greater vestibular adaptation to spaceflight
- Future study needed to determine amenability of OA and Cognition measures to treatment

## LIMITATIONS

- Small sample size
- Lack of in-flight OA data
- Potential confounders across test administrations (test fatigue, lighting, practice effects)

## IMPLICATIONS

- Comparisons between tests important for validation especially given the small sample size of astronaut studies
- We are currently assessing efficacy of self-administered rehabilitation methods for astronauts
- Opens the door to further study investigating synergies between various astronaut physiological tests