Sensory Cue Integration Differences For Heading vs. Scene-Relative Movement Tasks
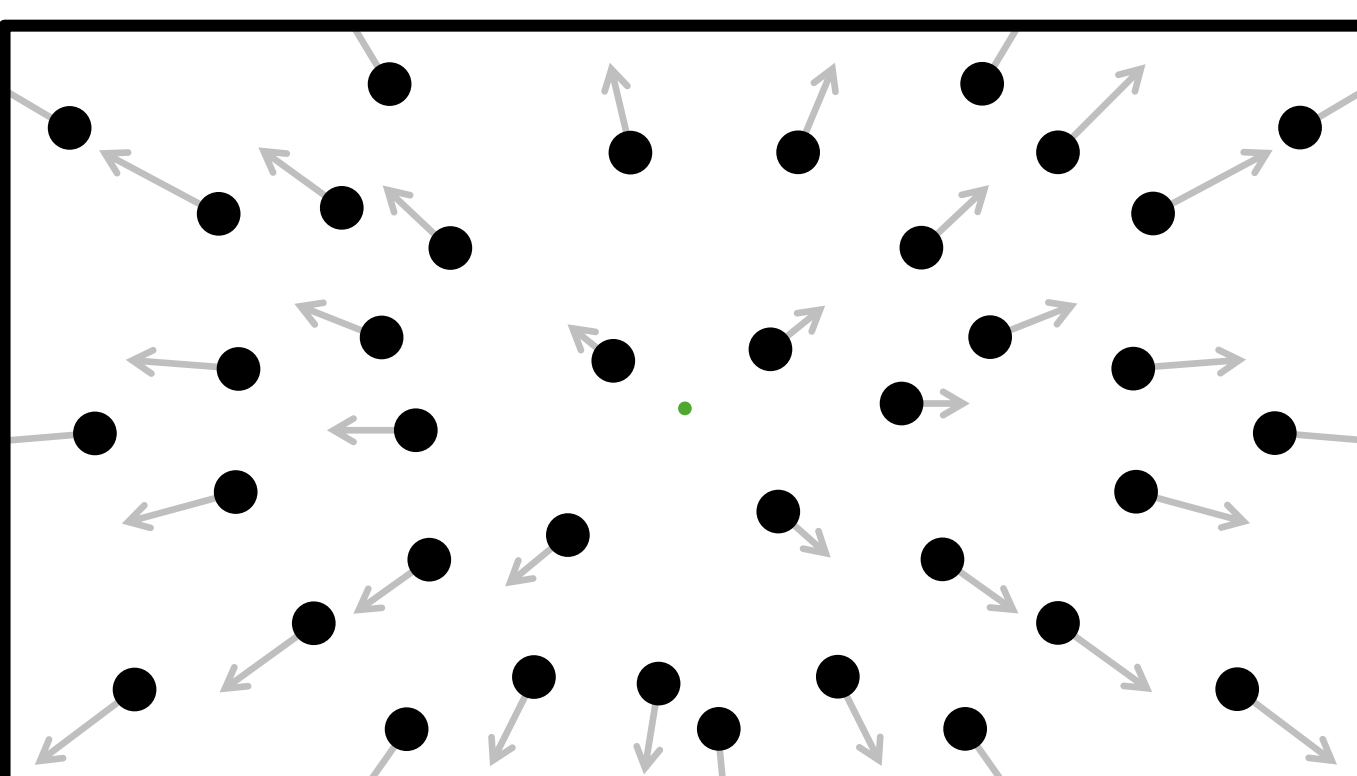
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Background

Heading Estimation

Estimate direction of self-movement

Multisensory process (visual, vestibular etc.), optimal integration should follow Maximum Likelihood Estimation (Ernst & Banks, 2002)

There is previous evidence for optimal integration (e.g., Gu et al., 2007; Yakubovich et al., 2020)

Scene-Relative Object Motion (S-ROM)

Estimate motion of an object within a visual scene

Need to distinguish between retinal motion due to observer movement and S-ROM

Another multisensory process, so should involve optimal integration

Improvement to S-ROM when visual and vestibular info together implies integration (MacNeilage et al., 2012)
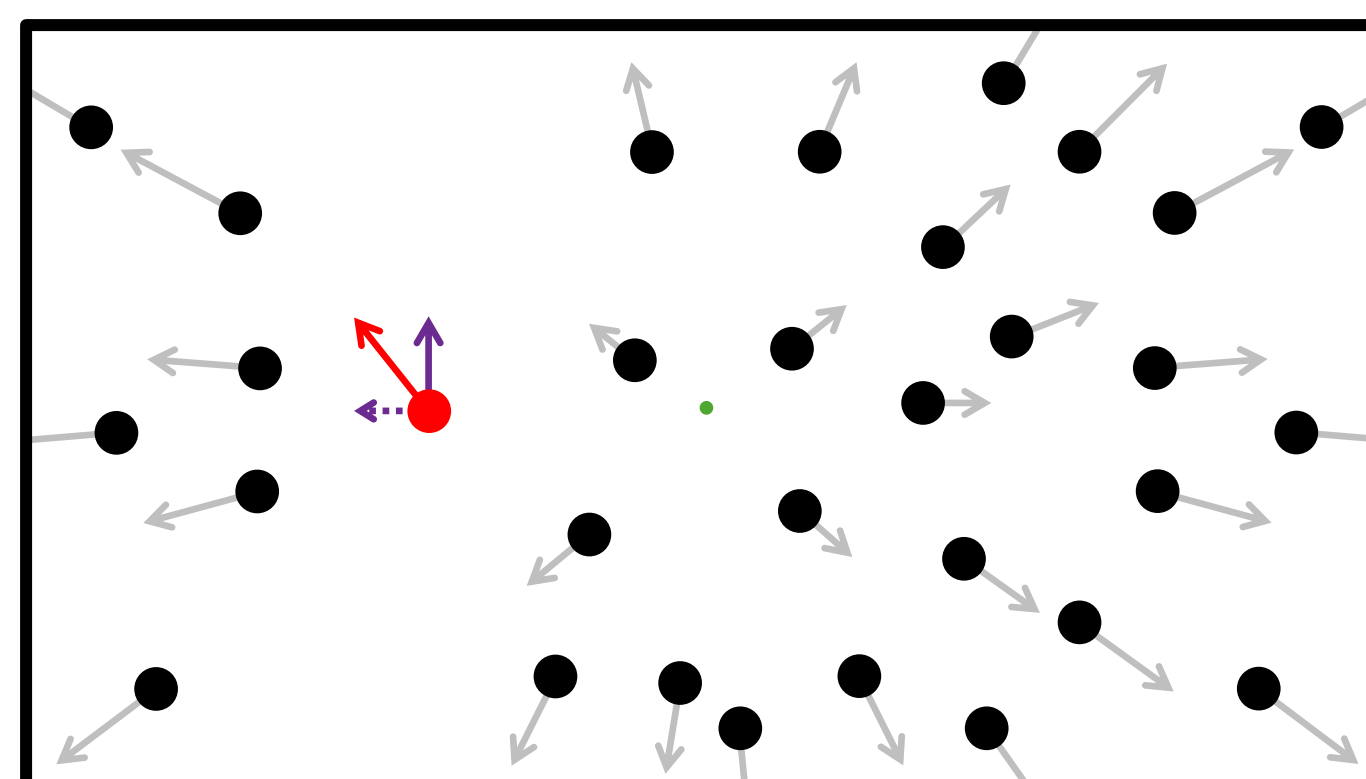
Similar Processes?

One way to recover S-ROM would be to estimate heading first, and use that estimate of motion due to observer movement to recover S-ROM

If we solve SROM by first estimating heading, the processes would be linked, and integration should be similar within participants

STARDUST

We are investigating the motion perception of people with Persistent Postural Perceptual Dizziness (PPPD) to better understand the mechanisms of PPPD and reduce symptoms through tailored VR therapy

The mechanisms of PPPD are not well understood. They may even vary across patients, with different symptom presentations hinting at subtypes of PPPD

If you know of anyone with PPPD who may be interested in participating, please contact Dr Joshua Haynes or scan the QR code to the right to view this poster and our participant advert.

Email: joshua.haynes@manchester.ac.uk

Design

Participants

23 participants (13F, 10M) aged 20-72
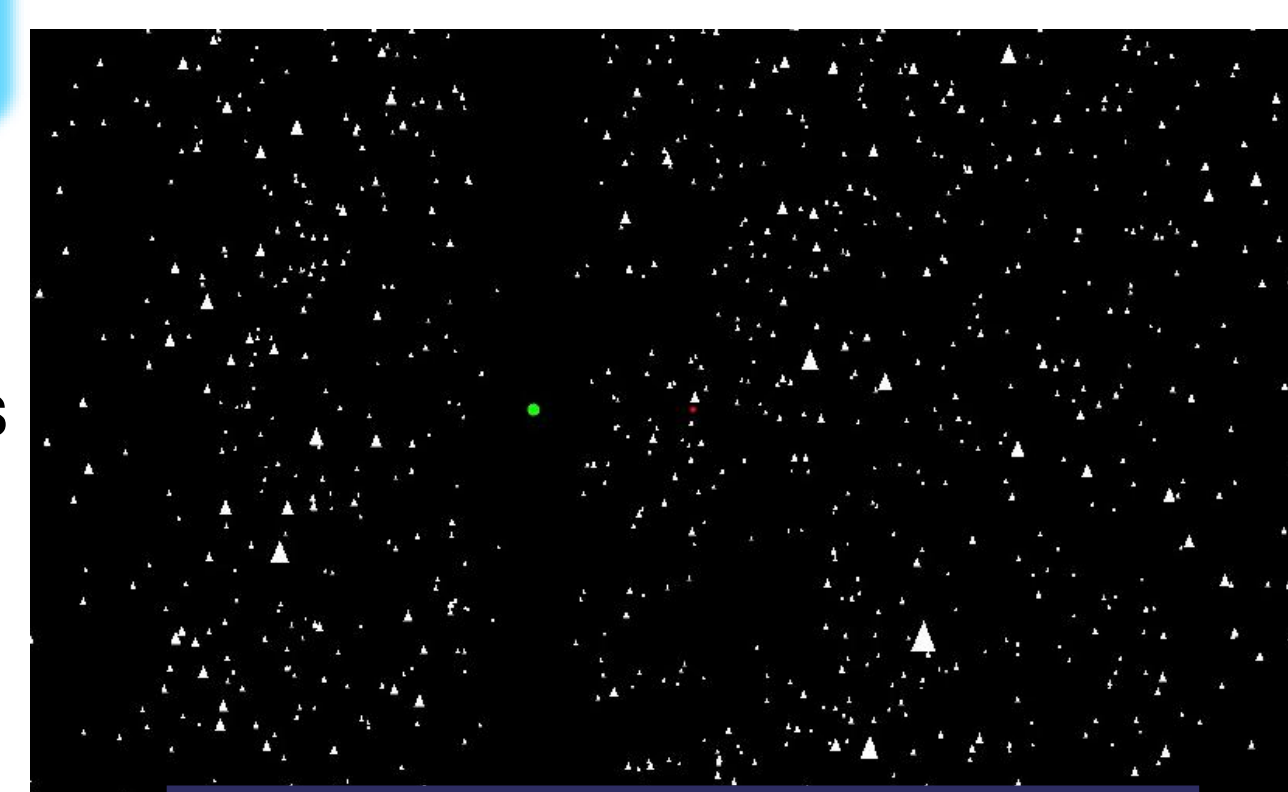Normal vision and no balance disorders

Stimuli

Visual: static observer, optic flow of star-field in Head-Mounted Display
Vestibular: moving observer on motion platform (no optic flow)
Multisensory: moving observer + optic flow
Linear forward movement with Gaussian speed profile (1s, max speed 0.31m/s)
Max heading direction +/-16degs
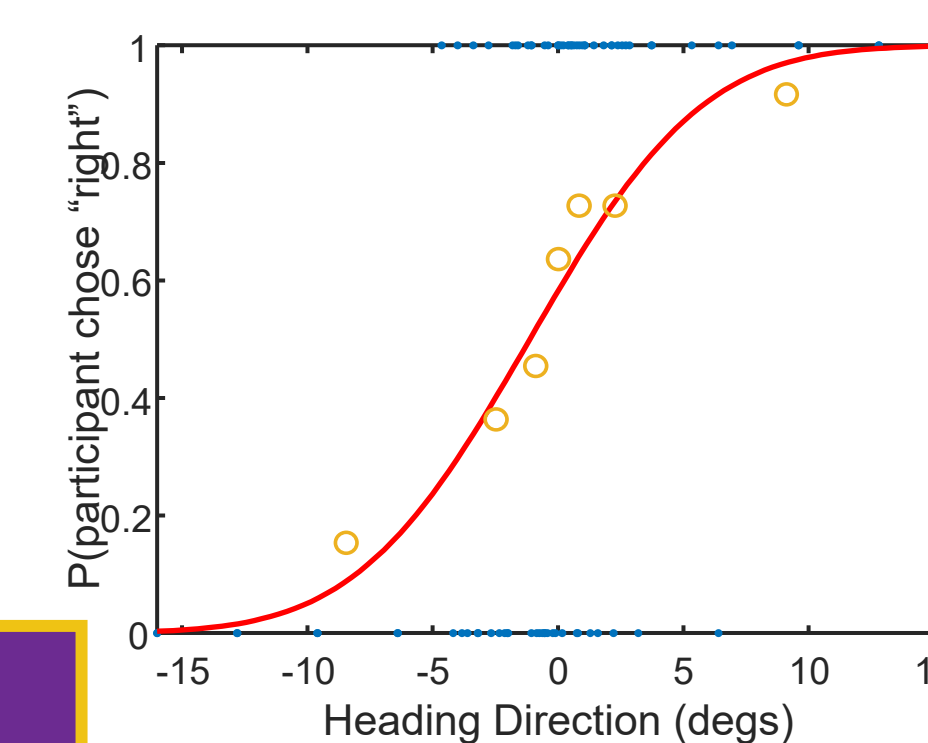Max SROM +/-16degs/s, vertical

Example Stimulus from SROM task

Method

Visual, Vestibular, and Multisensory conditions
In the heading task, two multisensory conditions had Δ±6 degs of bias added to the unisensory information
80 trials (4x interleaved Kesten staircases) in each
Psychometric functions (PMFs) fitted (Cumulative Normal). Bias and Threshold statistics recovered
Optimal biases and precisions calculated from unisensory conditions and compared to measured multisensory conditions
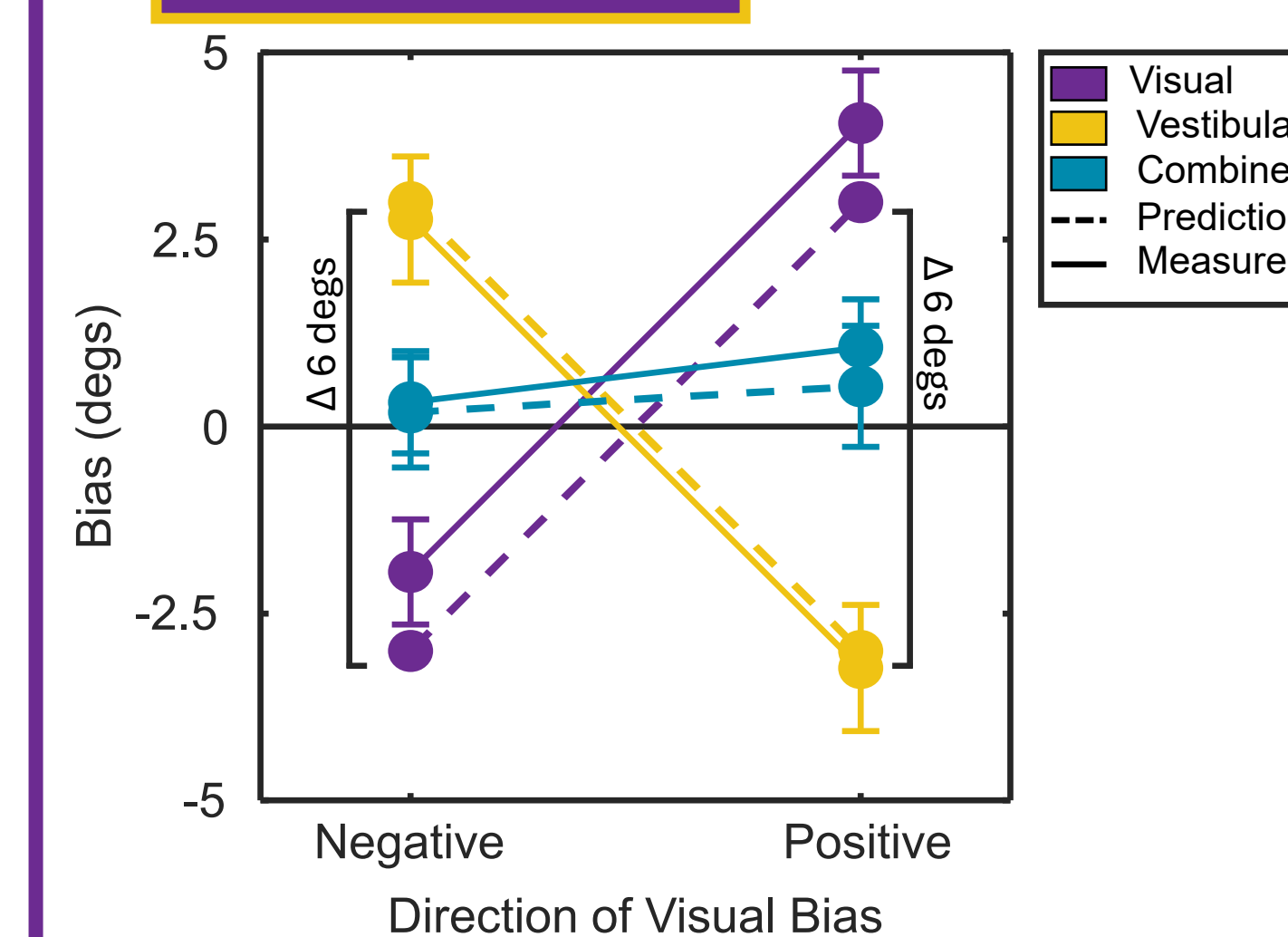
Summary and Conclusions

Some evidence for MLE integration in heading task (not significantly different from MLE prediction)

No evidence for integration in S-ROM task (significantly different from MLE prediction)

No evidence for correlation between integration in the two tasks which suggests that tasks are based on different processing

Results consistent with Warren et al (2012) who suggest that visual S-ROM recovery (Flow Parsing) does not depend on previously obtained heading estimate

Results

Heading Task

Bias data for the two multisensory conditions and the underlying unisensory information that they contain (unisensory data taken from unbiased unisensory conditions with Δ added as shown)

For bias analysis in integration, we need multisensory conditions that have differently biased unisensory information, to recover which biased signal is higher weighted

Biases are not significantly different from predictions in any condition

Visual: t(22) = 1.50, p = 0.59
Vestibular: t(22) = -0.27, p = 3.15
Multi (vis-): t(22) = -0.26, p = 3.19
Multi (vis+): t(22) = 0.99, p = 1.33

Perceptual thresholds in the multisensory condition are not significantly different from the optimal prediction

Optimal: t(22) = 2.2, p = 0.12

But are also not significantly different from the unisensory conditions (due to high variability in unisensory)

Visual: t(22) = 1.64, p = 0.35
Vestibular: t(22) = 2.01, p = 0.17

Some individual data is off the scales

SROM Task

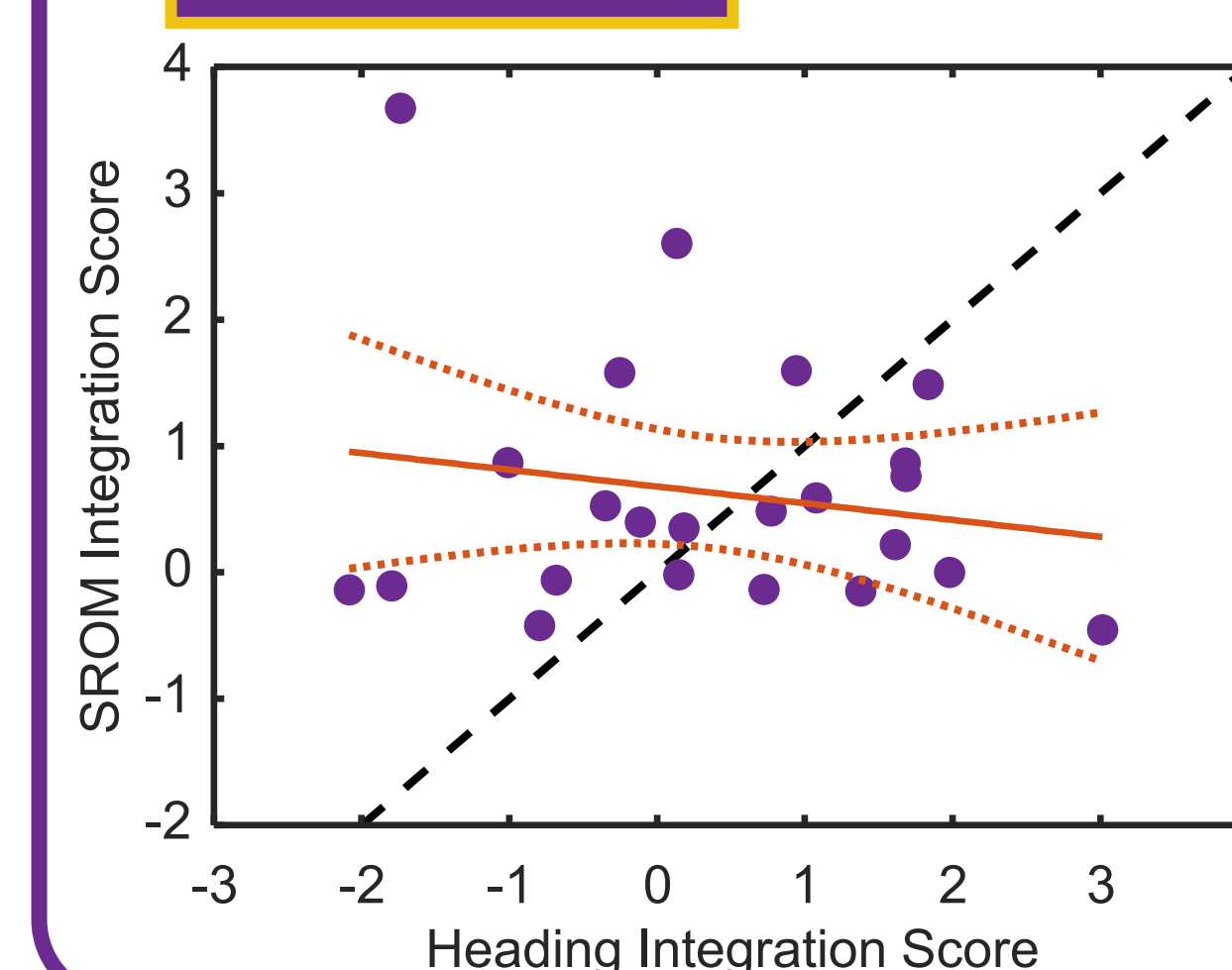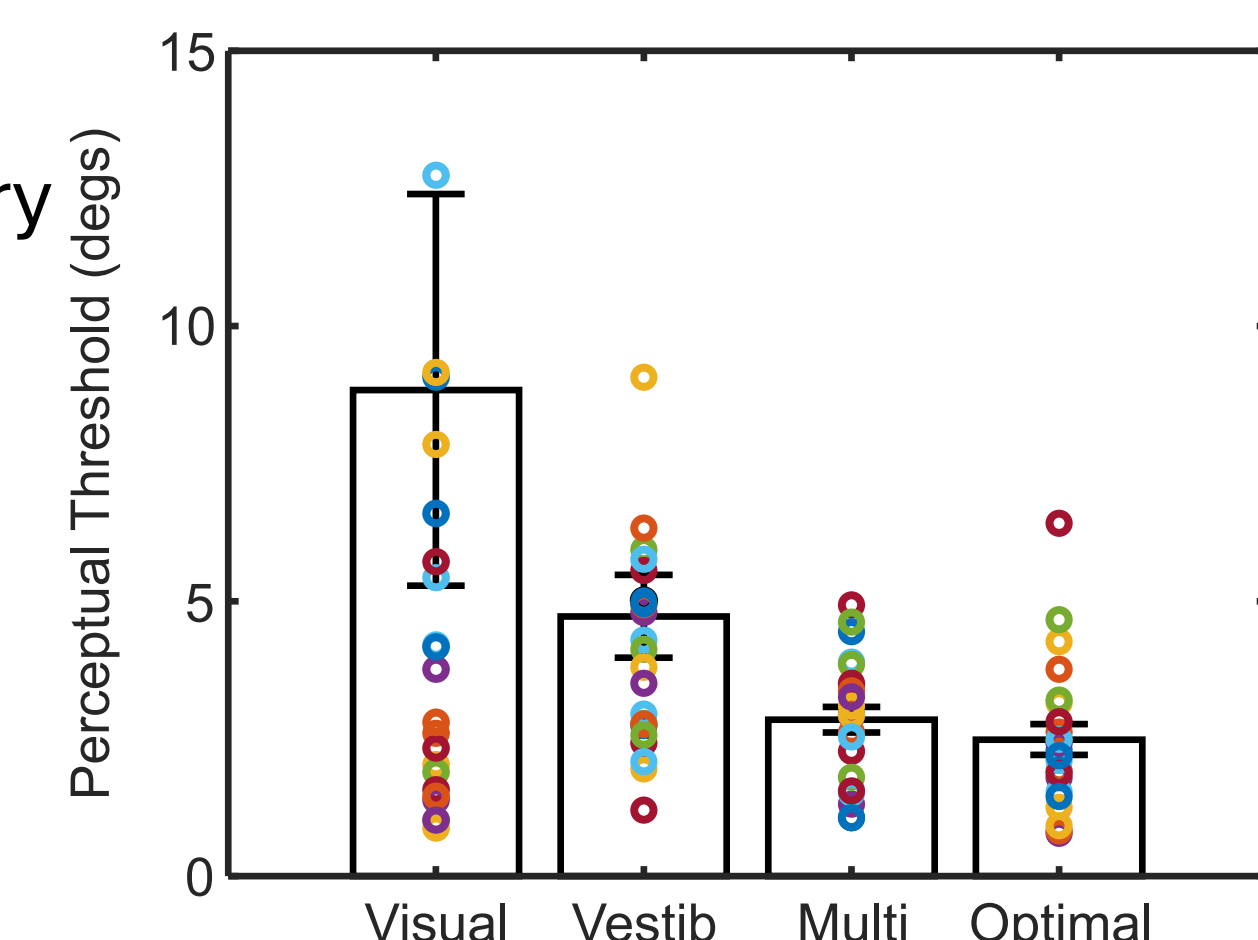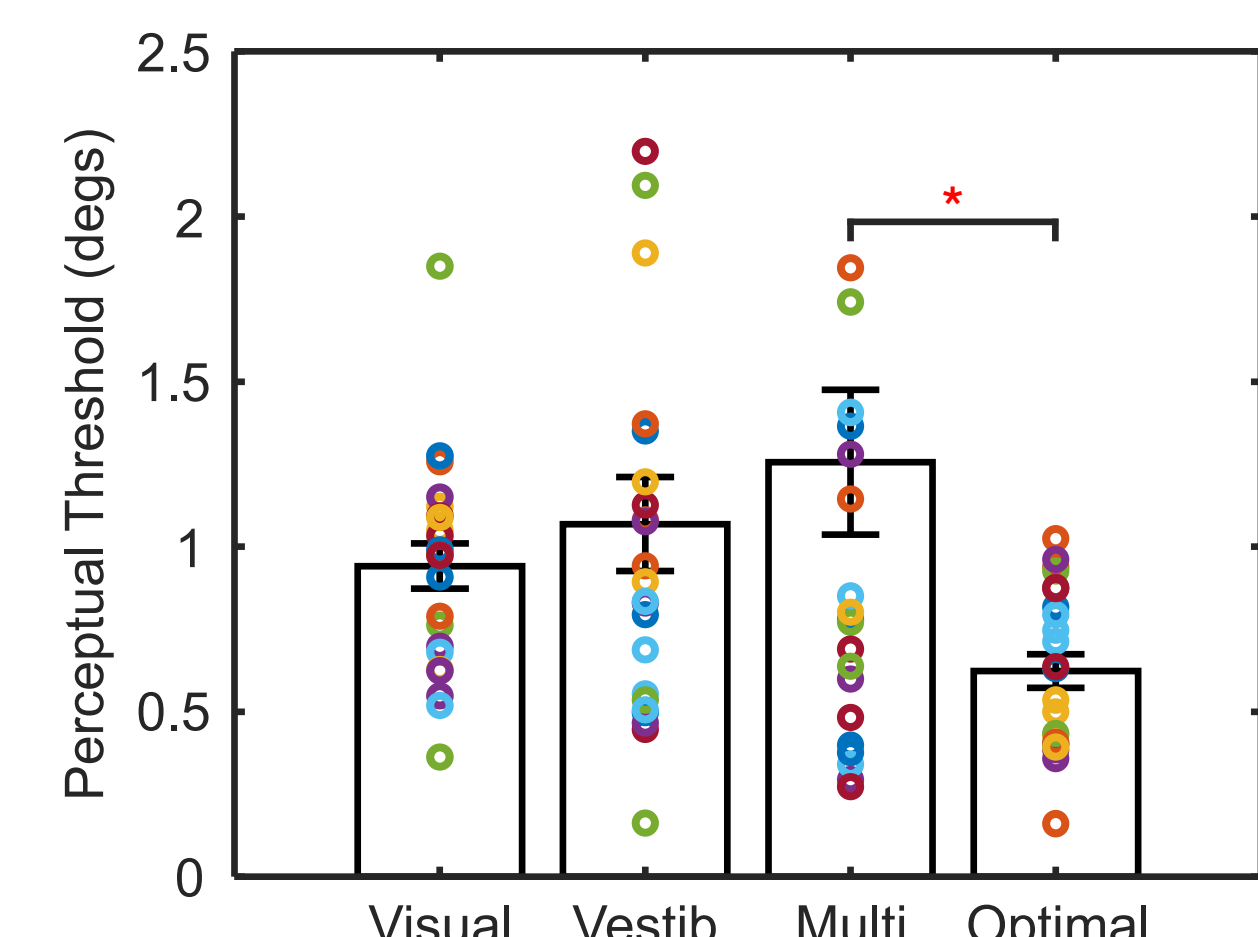Thresholds in the multisensory condition are significantly different from the optimal prediction

Optimal: t(22) = 3.02, p = 0.02*

And not significantly different from the unisensory conditions

Visual: t(22) = -1.47, p = 0.47
Vestibular: t(22) = -0.86, p = 1.2

Difference between prediction and measurement used as an integration score for individual participants on each task

Non-significant, negative correlation between the Integration scores in the SROM and Heading tasks
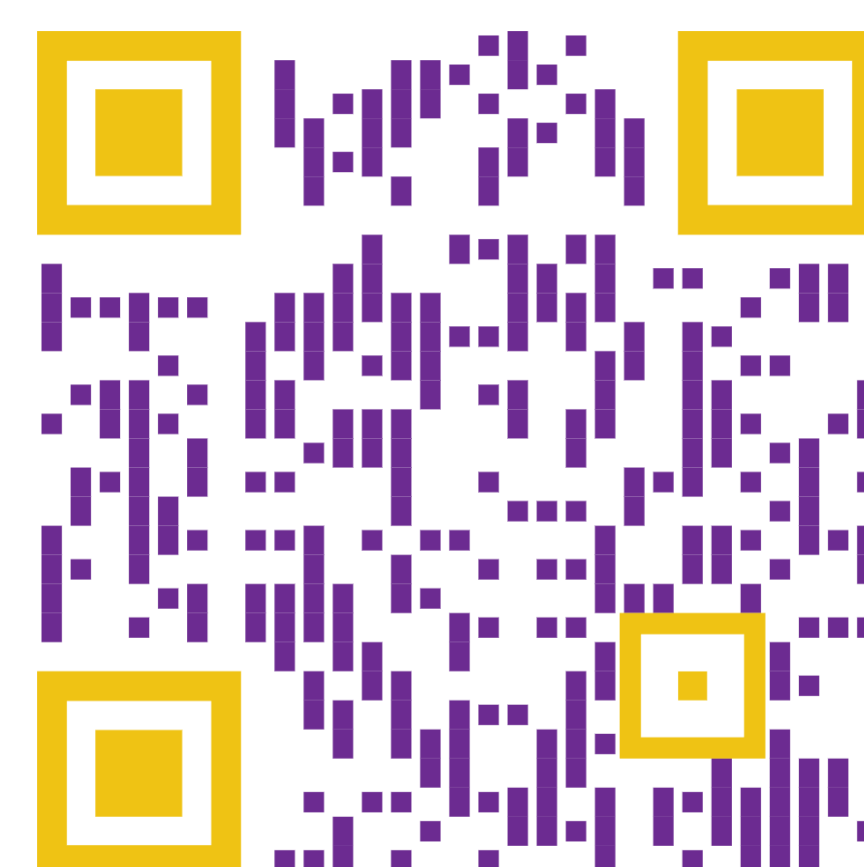
Correlation: R(21) = -0.18, p = 0.42

Correlation

All T-tests are Bonferroni corrected

STARDUST
Study to Assess and Reduce
Dizziness Using Sensory Theory

MANCHESTER
1824
The University of Manchester

PERSISTENT POSTURAL PERCEPTUAL DIZZINESS (3PD)?

STARDUST is a UK-wide study to investigate the causes of 3PD symptoms, so that we can ultimately design new therapies

Participants will visit our Manchester laboratories to take part in simple experiments (some in VR) assessing their perception of movement. You will also need to undergo a screening interview and complete some baseline tests (IQ, visual acuity) and questionnaires to characterise symptoms

Participants will be compensated for their time & reasonable travel expenses

If you are interested in taking part in our study and would like to know more/discuss eligibility then please contact:
Dr. Joshua Haynes (joshua.haynes@manchester.ac.uk)

Participants must:

- Be aged 18+ and have a formal diagnosis of 3PD
- Have an MRI scan performed within last 10 years of the Brain/Auditory Meatus
- Have normal or corrected to normal eye sight
- Be willing and able to travel to Manchester for two half day testing sessions
- Be able to easily understand verbal/written explanations in English
- Have no other diagnosed neurological, cardiac, visual or psychological conditions