Visuo-Vestibular Integration in Healthy Controls: Pilot Data for an Investigation into Motion Perception of PPPD Patients

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Background

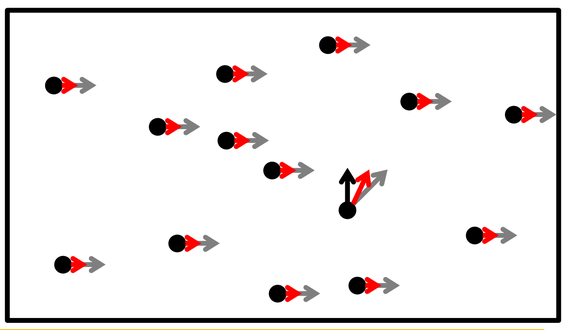
Optic Flow Parsing

Purely visual mechanism

Acts to compensate for visual consequences of self-movement

Consequence of Self Movement

Object Movement | Perceived Movement



Detecting Scene Relative Movement

Use self-movement estimates to predict motion in the image

Look for mismatches between the estimate and our self-movement signals

Vestibular information

The vestibular system also provides us with self-movement information

Do we use it to detect scene relative movement?

Visuo-Vestibular Integration

We often combine sensory information from different sources

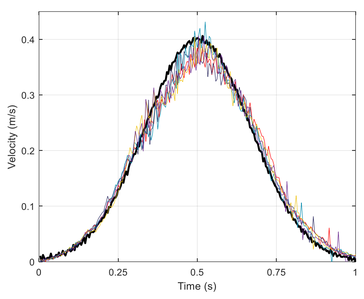
This can include visual and vestibular information about self-movement

What about visual and vestibular information about scene relative movement?

Design

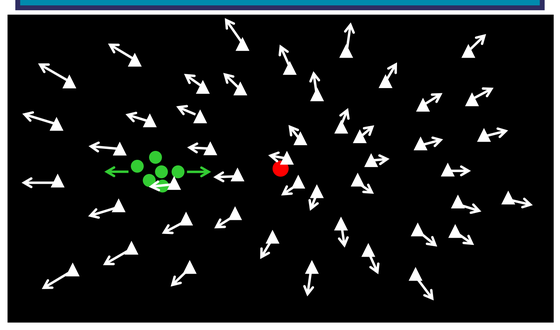
Movement

Measured the movement of the platform with Optitrack system



Black line represents the target (with simulated noise)

Scene Relative Movement Task



Again, moved vestibular only, visual only, or combined

Dots moved left or right in space (perpendicular to movement direction)

Asked if the cloud of dots moved left or right in the world

Movement of the green dots controlled by four Kesten staircases

Participants

Data from 6 control participants is presented here. Participants self-report normal or corrected to normal vision

Heading Task

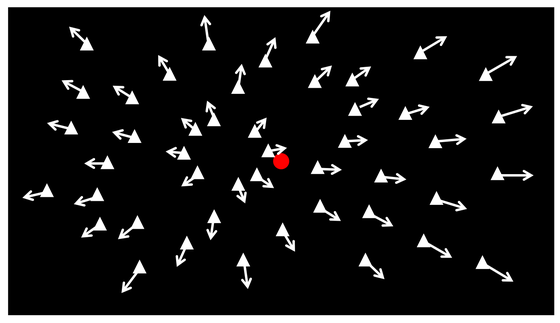
Moved physically on motion platform (vestibular only), virtually through cloud of triangles (visual only), or both (combined).

Gaussian movement with top speed 0.4m/s and duration 1s.

Asked which side of straight ahead they moved (or simulated movement was)

Movement direction started at +/-16degs and changed with four Kesten staircases

Two combined conditions, one with vestibular information 6degs to the left of visual information and vice versa



Results

Ernst, M. O., & Banks, M. S. (2002). Humans integrate visual and haptic information in a statistically optimal fashion. Nature, 415(6870), 429-433.,

Data from unisensory conditions used to predict outcomes of multisensory conditions using the MLE (optimal integration) model (e.g., Ernst and Banks (2002)

Heading Task

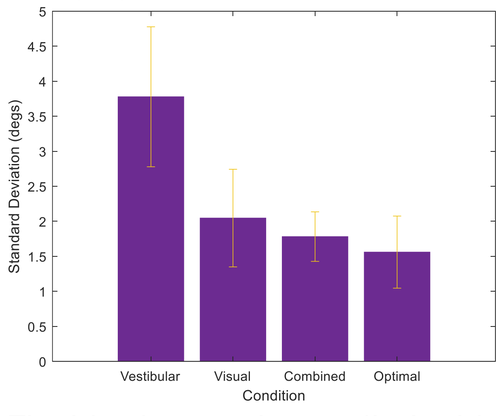
Precision

$$\frac{1}{\sigma_T^2} = \frac{1}{\sigma_{Vis}^2} + \frac{1}{\sigma_{Ves}^2}$$

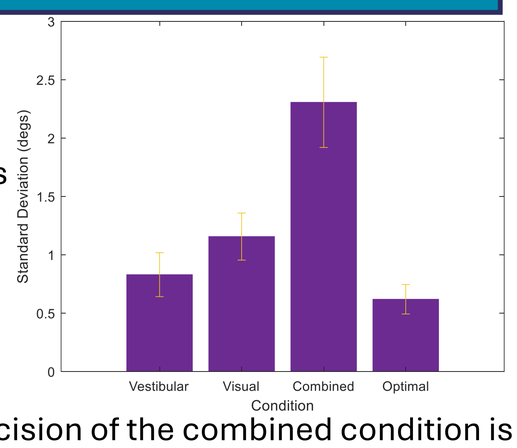
Threshold of psychometric functions used to determine precision

Collapsed across the two combined conditions

The precision of the combined condition is better than each unimodal condition and nearly optimal



Scene Relative Movement Task



The precision of the combined condition is worse than either unimodal condition

It is unlikely that integration is occurring

Instead of integration perhaps signals treated as independent (variances add)

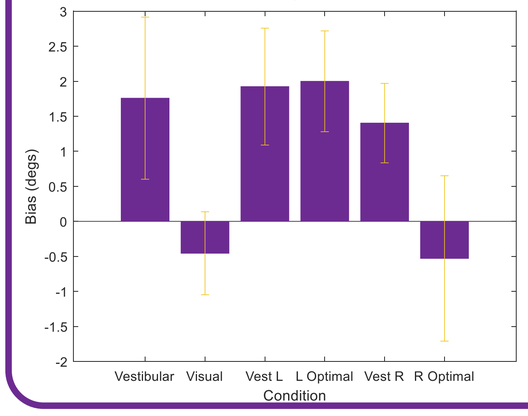
Bias

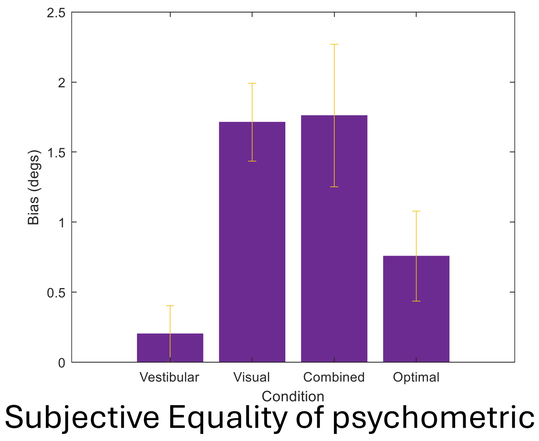
$$w_{vis} = \frac{\sigma_{ves}^2}{\sigma_{vis}^2 + \sigma_{ves}^2}$$

$$b_T = w_{vis} b_{vis} + w_{ves} b_{ves}$$

The bias is near the vestibular bias and appears nearly optimal in one combined condition but not so optimal in the other

We may be overweighting vestibular information compared to visual





Point of Subjective Equality of psychometric functions used to determine bias

The bias is near the visual bias and not optimal

Again, adding the biases seems more apt

STARDUST

We are investigating the perception of people with 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

This pilot data is from preparation of experiments for use with our patient population, data collection is ongoing for these tasks alongside others.

PPPD

Functional Neurological Disorder

Symptoms include a chronic underlying dizziness and severe bouts of dizziness that are caused by events as simple as standing up or a busy visual environment

Integration Hypothesis:

PPPD patients may overweight visual information during visuo-vestibular integration

The heading task used here adapts the methods from Yakubovich et al. (2020) who found that people with Parkinson's disease overweight visual information even though their processing of visual information is impaired

It is possible that the same finding (overweighting of visual information) could explain the symptoms of PPPD

If you know of anyone with PPPD who may be interested in participating in this research, please speak with me or scan the QR code below to view our participant advert.

Yakubovich, S., Israeli-Korn, S., Halperin, O., Yahalom, G., Hassin-Baer, S., & Zaidel, A. (2020). Visual self-motion cues are impaired yet overweighted during visual–vestibular integration in Parkinson's disease. *Brain communications*, *2*(1), fcaa035.

Summary and Conclusions

- **We present pilot data for two experiments that investigate visuo-vestibular integration**
- **In the heading task, it appears that participants do integrate, though they may do so with sub-optimal weighting**
- **In the Scene Relative Movement task, it appears that participants do not integrate and instead show behaviour that is more in line with treating the cues as independent**

SCAN HERE:

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

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