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# Shared brain areas underlying imagined and perceived self-motion

Cognitive and Motor Functions of the Vestibular System Workshop

Aix-Marseille Université, Marseille

5-6th July 2018

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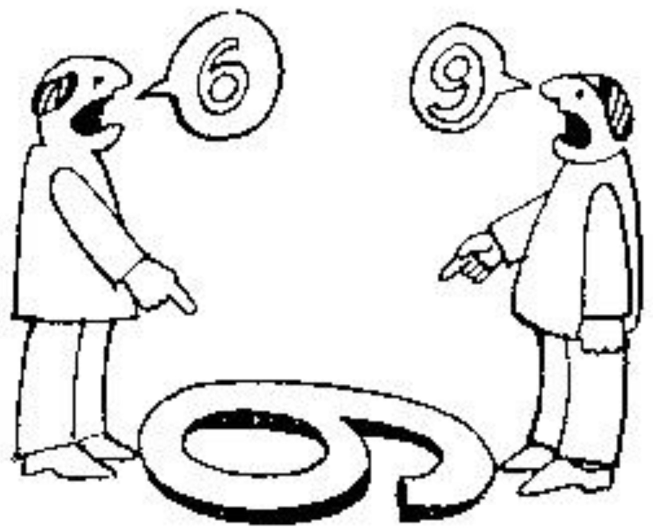
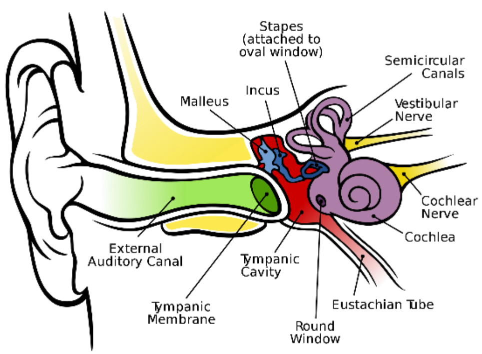
Department of Psychology, University of Bern

# Mental changes of self location



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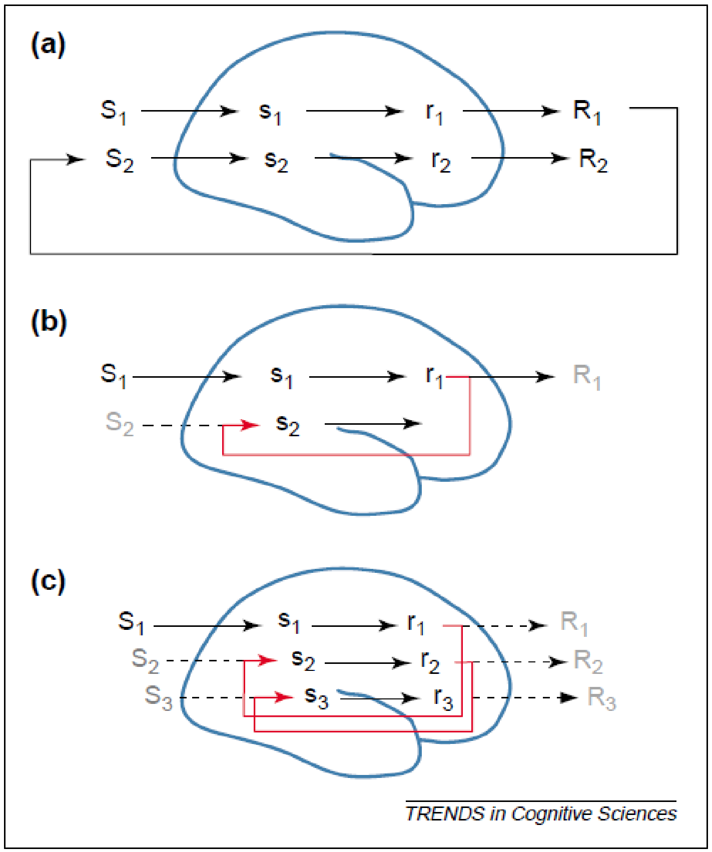
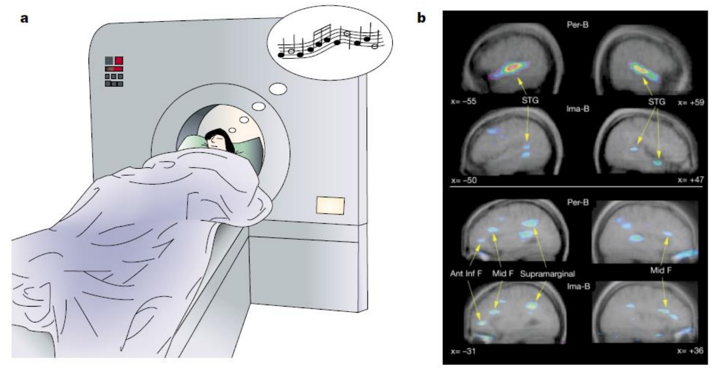
# Mental Simulations & Neural Correlates

## Idea

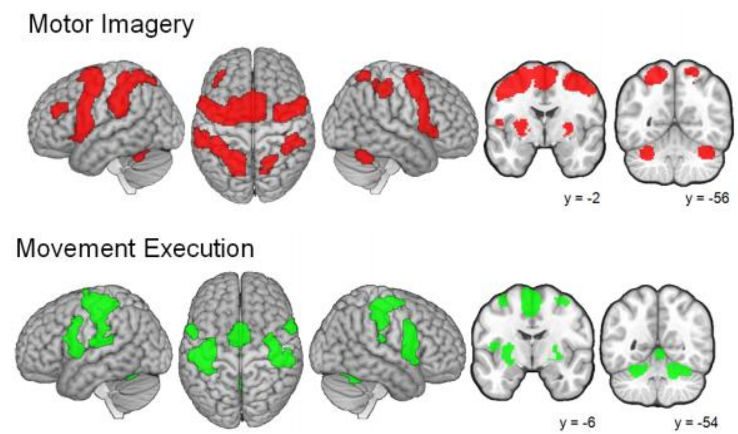



Hesslow, 2002

## Neural Level



Kosslyn et al., 2001




Hardwick et al., 2017, bioRxiv

# Vestibular imagery?

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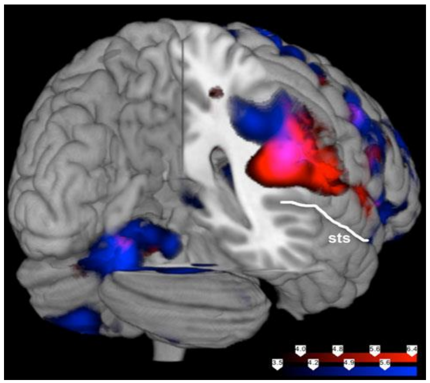
## Vestibular Recall & Imagery



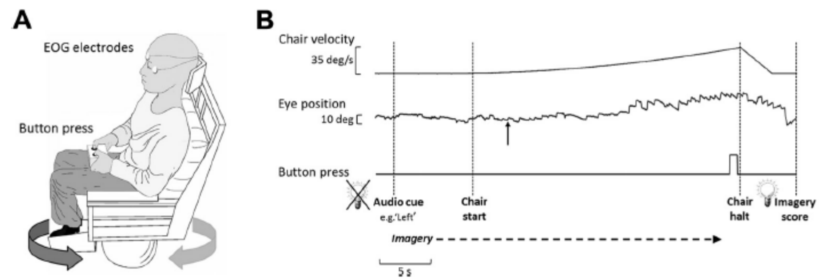

### No vestibular areas involved in recall

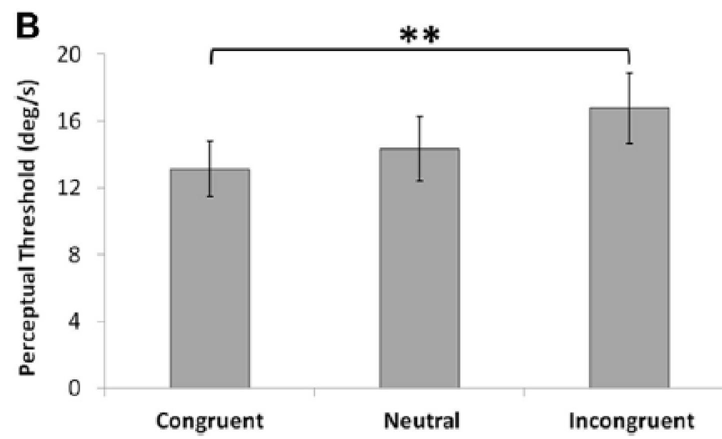
In contrast to the galvanic vestibular control experiment, we did not detect activations in the parietal operculum, the posterior insula (PIVC) or the superior temporal gyri. Other essential gateways within the cortical vestibular network like the hippocampus or the dorsolateral thalamus were also unresponsive during our vestibular recall task (Dieterich et al. 2005; Smith et al. 2010). All of which are well-known

### Very difficult

cause the rating (Logie et al. 2011). Hence, we feel that the high degrees of difficulty in recalling a vestibular sensation and the missing activation of core regions within the vestibular network during the recall task suggest a hindered voluntary access to cortical vestibular areas.

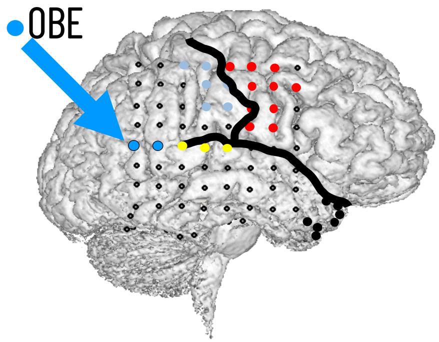
Zu Eulenburg et al., 2013




Nigamatullina et al., 2015

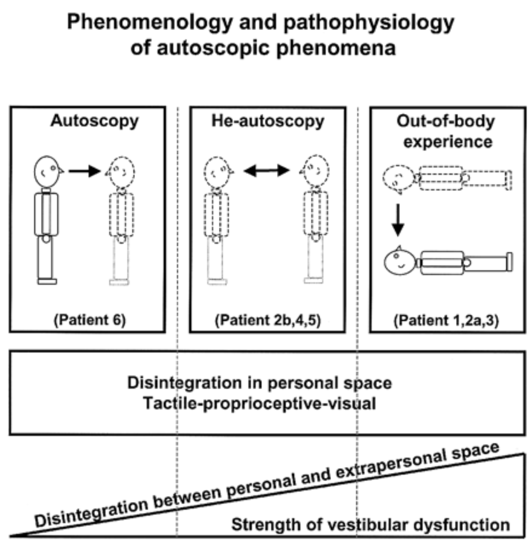
# Why is this relevant?




Falling (2.5-3.0 mA)

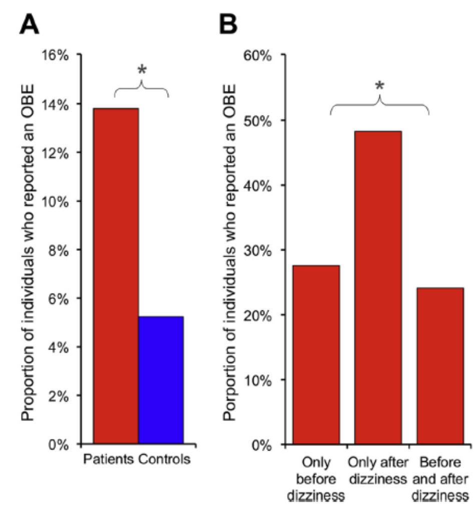
OBE (3.5 mA)

Blanke et al., 2002




Blanke et al. 2004

## OBE in vestibular disorders




Lopez & Elzière, 2017

# Mental self-rotation & Vestibular proccessing

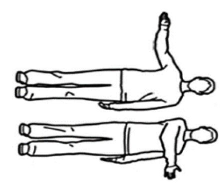
## Idea: Areas involved in self-motion are also involved in simulated self-motion

**Microgravity**

Grabherr et al. 2007

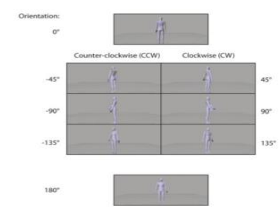
**GVS**

Lenggenhager et al. 2008
Dilda et al., 2011



**CVS**

Falconer & Mast, 2012




**Passive self-motion**

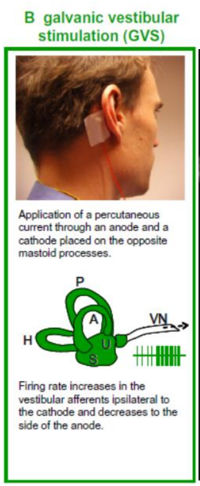
Van Elk & Blanke, 2014
Deroualle et al., 2015

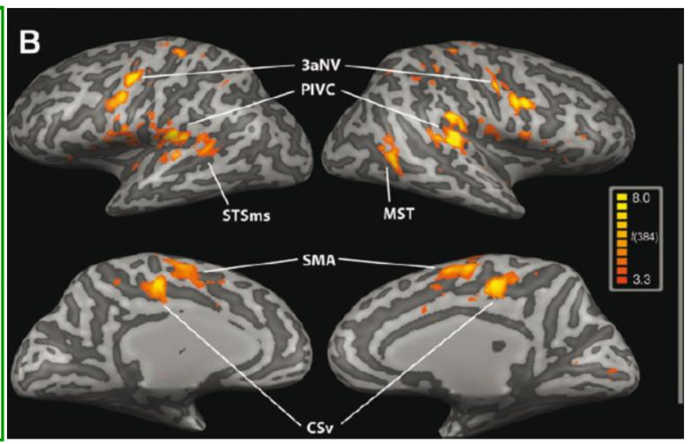
➔ Mental body transformations
(simulated change in self-location)

Inconclusive results: Conflicting stimulations, Individual strategies

## Which cortical areas are involved in vestibular processing and simulated self-location changes?

### GVS: Method & neural correlates

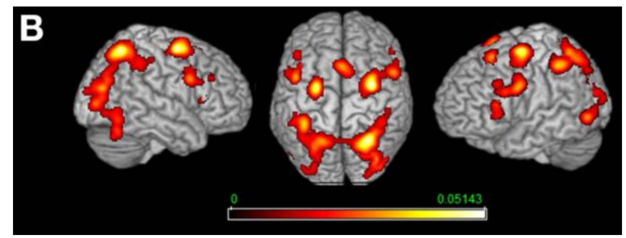



Lopez et al., 2012

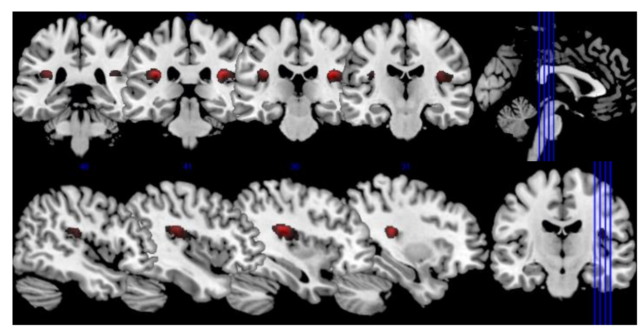
Smith et al., 2012

### Mental Rotations




Tomasino et al., 2016

### Area OP2



Eickhoff et al., 2006

# Current study: Two aims

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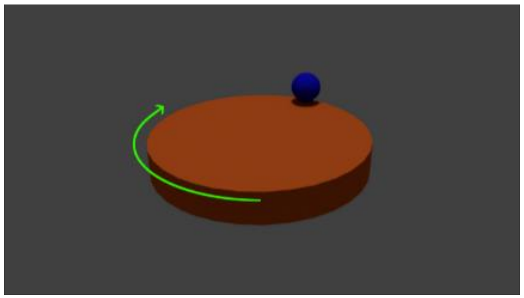
1. Cortical overlap of *simulated* and *perceived* self-motion
   - Simulated = egocentric mental rotation
   - Perceived = GVS

2. Behavioral effects of GVS on simulated self-motion

# Mental Rotation & Vestibular Stimulation

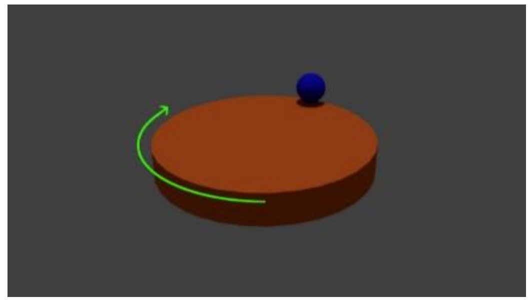


Egocentric Rotation



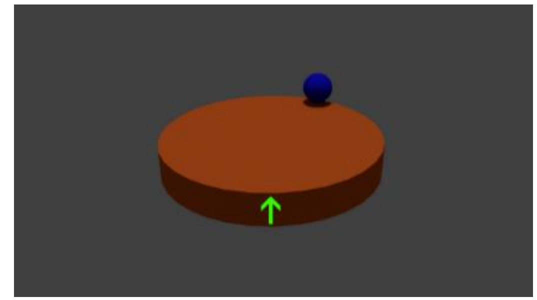
Left

Object Rotation



Right

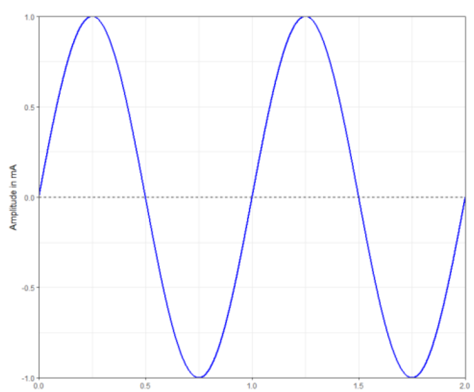
No Rotation



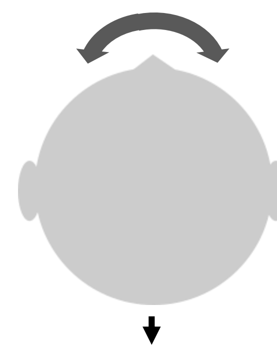
Right

Keehner et al., 2006

## GVS Signal

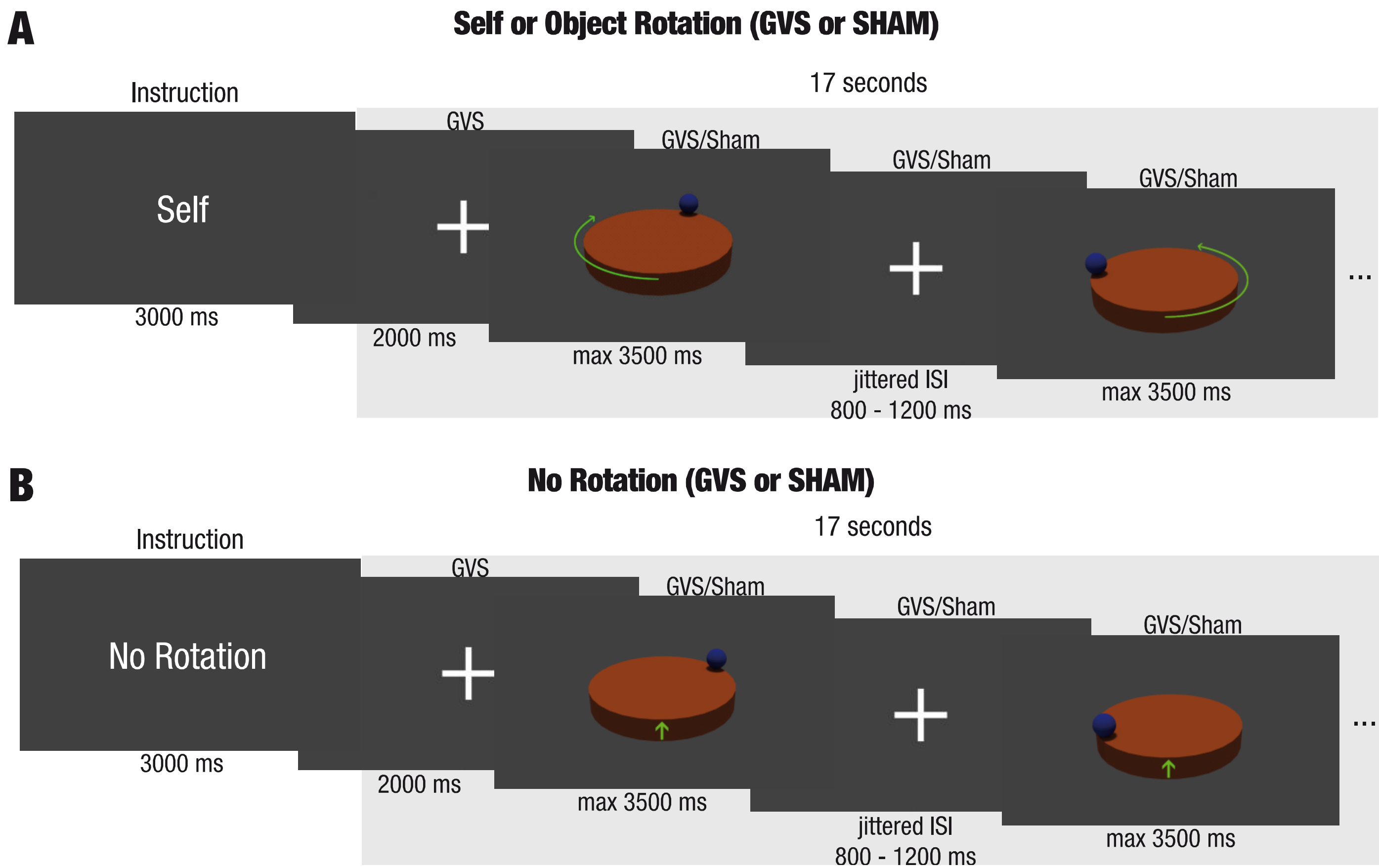



## Sensation



Gravity

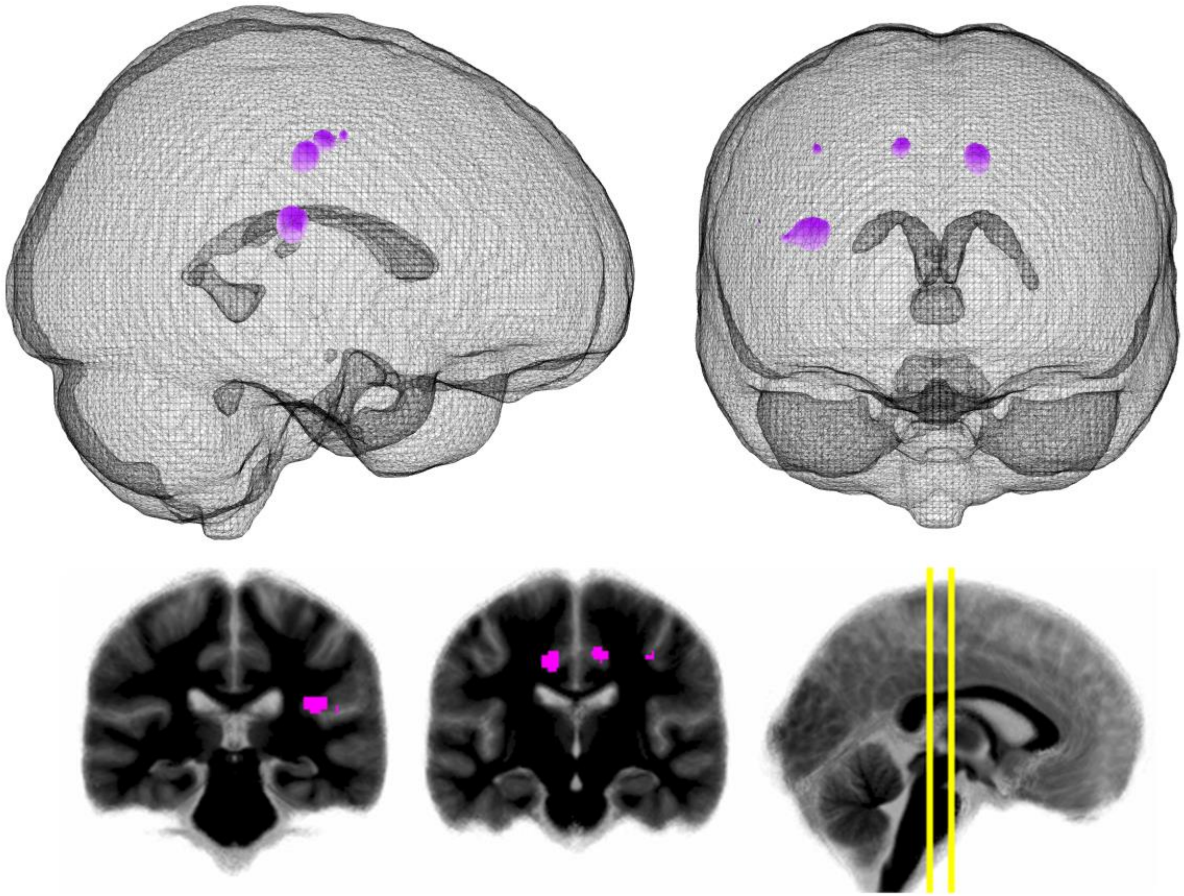
# fMRI Design




3 (Egocentric, Object, No Rotation) x 2 (GVS, Sham) Design

# Main effect of GVS

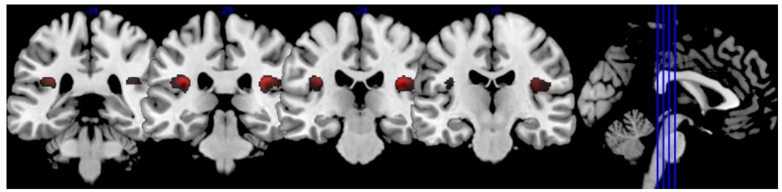
GVS vs Sham over all rotation tasks



pFWE < 0.05

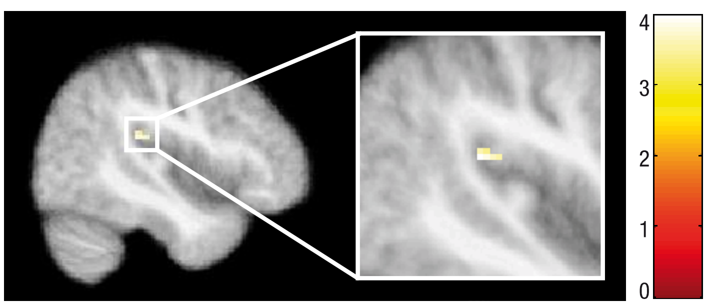
# Conjunction analysis: Area OP2 I

Area OP2



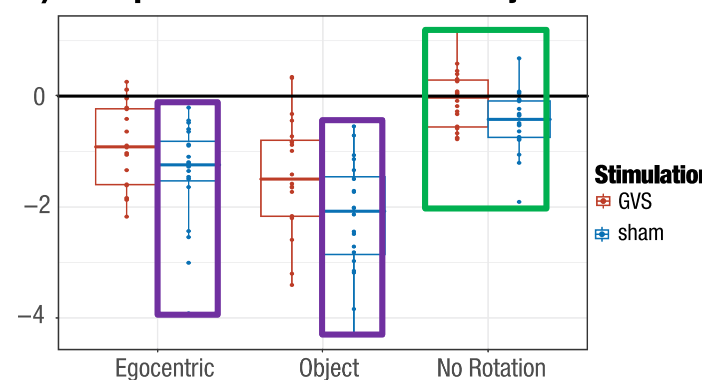
Vestibular processing & egocentric mental rotation

**A) Conjunction egoncentric rotation & vestibular processing in OP2**




pFWE-SVC = .039

**B) Mean parameter estimates from conjunction in OP2**



# Current study: Two aims



1. Cortical overlap of *simulated* and *perceived* self-motion
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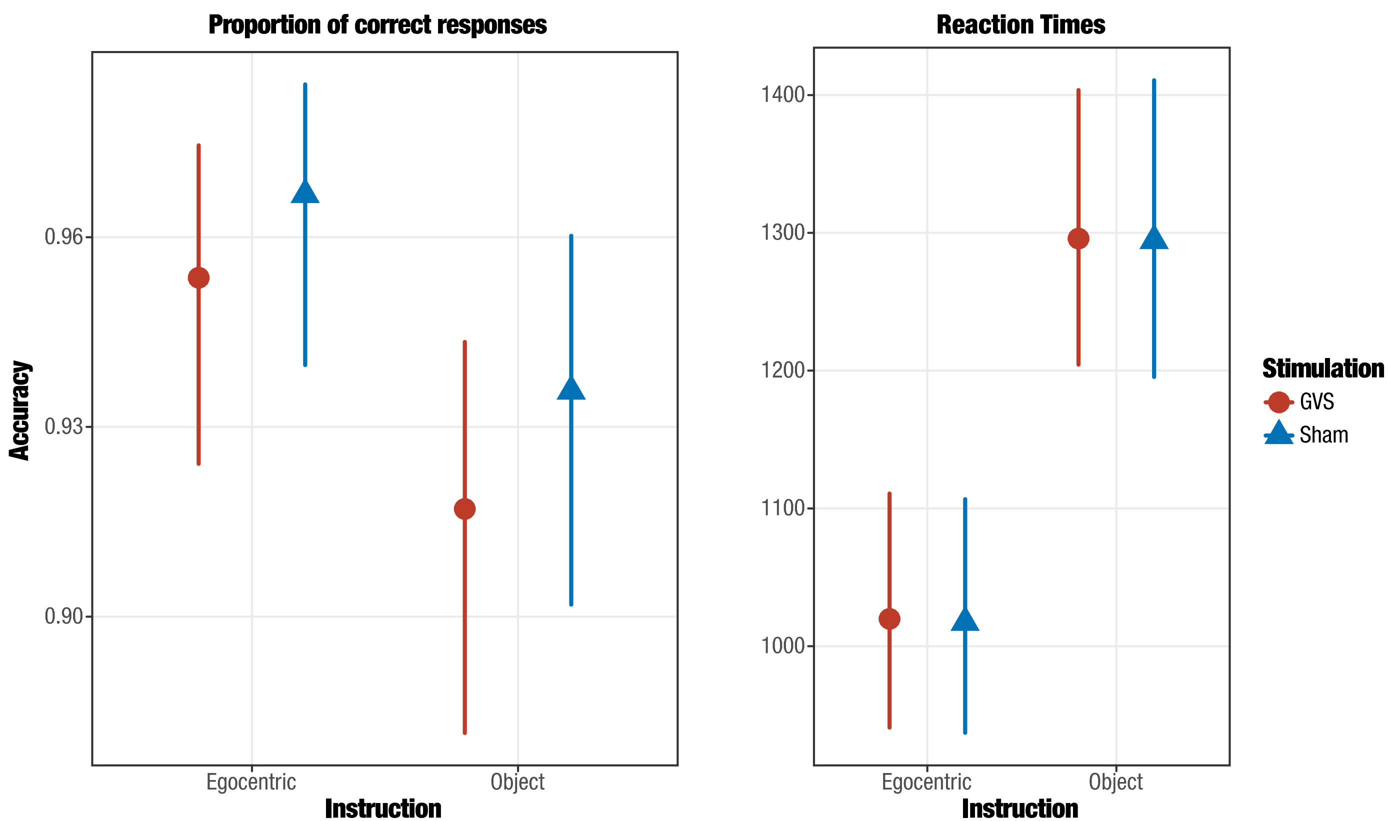
# Accuracy & Reaction Times



# Conclusion



> Vestibular brain areas are involved in egocentric mental rotation.

> First evidence that *vestibular processing* and *egocentric mental rotation* rely on shared area in the vestibular cortex (area OP2)

> No effect of GVS on egocentric mental rotation
- Robustness to interference?
- Task difficulty?
- Difference to body rotation task?

# Acknowledgment

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Thank you for the attention

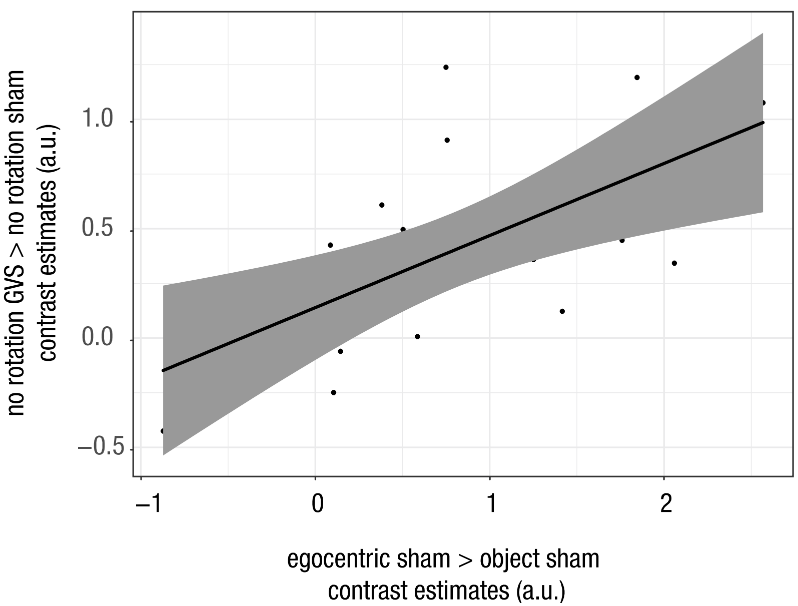
# Conjunction analysis: Area OP2 II

## *Post hoc* correlations

Shared area involved in egocentric mental rotation and vestibular processing

Brain-Behavior relationship: The higher the difference, the faster the responses

**C) Contrast estimates OP2 conjunction**




**D) Contrast estimates & Reaction Times – OP2 conjunction**