Shared neural mechanisms between imagined and illusory egocentric motion

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Introduction

Egocentric mental rotation (ECM) is suggested to be at the base of more complex social tasks, e.g. taking the spatial perspective of others.

The vestibular system codes self-motion and self-orientation in space. Both aspects are crucial in actual self-rotation and are likely involved in mental changes of self-location[1]. Several behavioral studies have investigated the link between vestibular processing and ECM. Thus, it has been suggested that ECM is based on brain areas that are also involved in processing actual self-motion, i.e the vestibular cortex[2].

Aim

To locate brain areas in the vestibular cortex that are involved in both vestibular processing and in ECM within the same individuals using fMRI and GVS.

Conclusion

The current study provides first evidence that both vestibular processing and egocentric mental rotation rely on overlapping areas within the vestibular cortex. Thus, vestibular areas are also activated when self-rotation is imagined while there is no vestibular sensory input causing the activation.

Methods

20 preselected healthy participants underwent the fMRI experiment. In the fMRI they performed mental rotation tasks[3] (fig 1), while they experienced sinsusoidal Galvanic Vestibular Stimulation (GVS). A within-subject 3 (egocentric, object, no rotation) x 2 (GVS, sham) design was used.

To reveal the overlap of brain areas involved in ECM and vestibular processing, a conjunction for the contrasts *ego > object rotation & no rotation GVS > sham* was calculated.

Based on previous literature investigating GVS[4] the vestibular cortex was defined as area OP2 in the parietal operculum.

Analyses were performed in SPM12 (Matlab) and R (brms package).

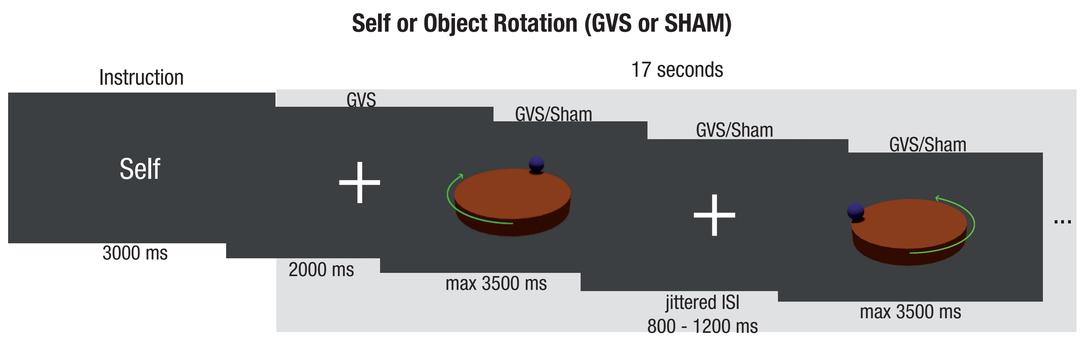


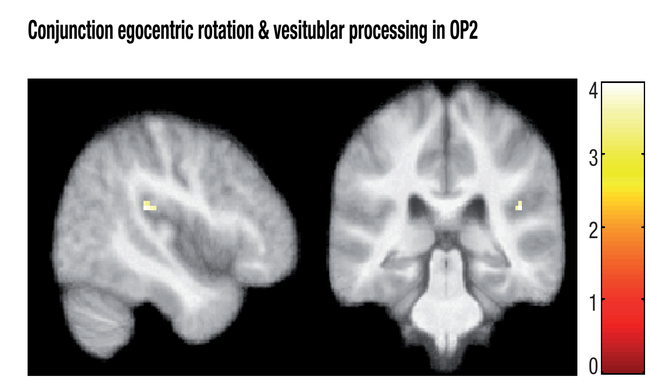
Fig.1: A depiction of the fMRI task. For every trial participants had to either mentally rotate to the top of the arrow (ECM) or rotate the table with the ball on it in the direction of the arrow (object). They were instructed to indicate the ball's position after the mental rotation as fast and accurately as possible.

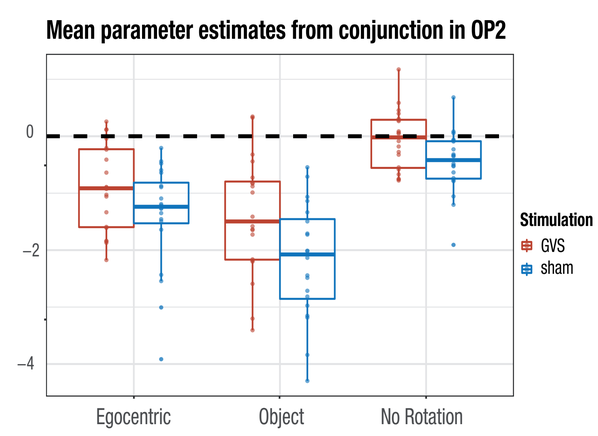
fMRI Results

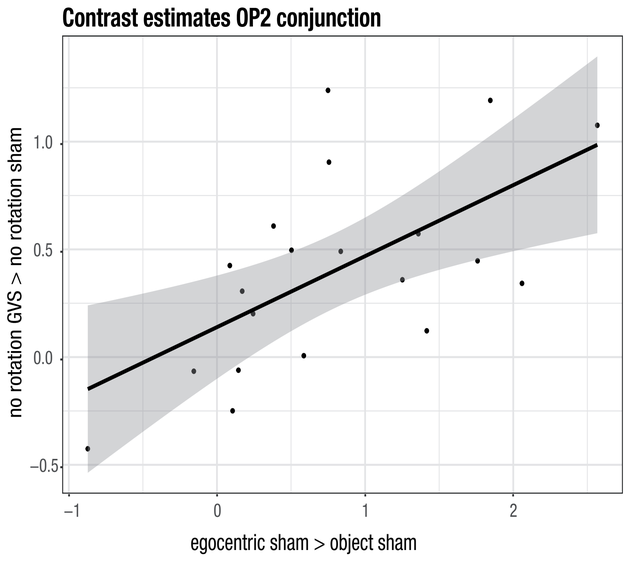
As predicted, the data show an overlap of brain activity within the area OP2 for both egocentric mental rotation and vestibular processing (voxel level threshold svc-corrected, *pFWE* = 0.039, see fig 2). The positive correlation of the contrast estimates (*ego > object sham and no rotation GVS > sham*) highlights the shared vestibular areas within the same individual.

Behavioral Results

Bayesian multilevel regressions for participants' accuracy (logistic regression) and reaction times revealed no influence of GVS on the behavior. However, there was a meaningful influence of the rotation strategy on the behavior. The egocentric mental rotation was easier (fig 3).







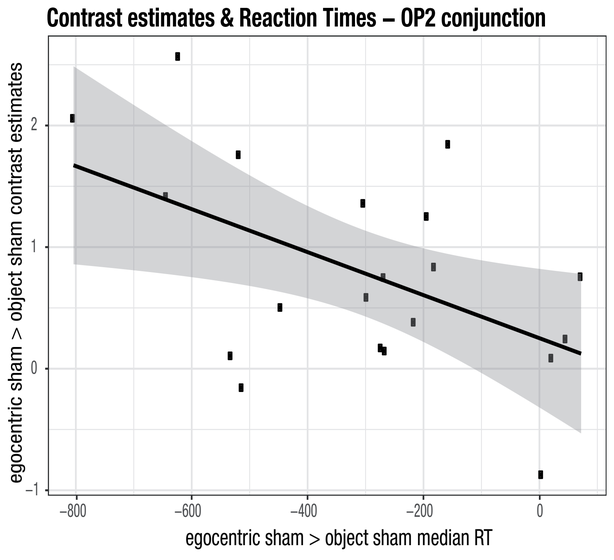


Fig.2: **On the upper left**, the results from the conjunction analysis for the contrasts egocentric sham > object sham & no rotation GVS > no rotation sham within the area OP2. **On the upper right**, boxplots for the mean parameter estimates for the cluster presented on the left for each participant. **On the lower left**, the positive correlation indicates, that participants with more activation in the egocentric sham condition also show more activation in the no rotation GVS condition. **On the lower right**, the negative correlation indicates that the faster the participants responded in the egocentric as compared to the object condition, the higher the positive activation difference within the cluster in area OP2.

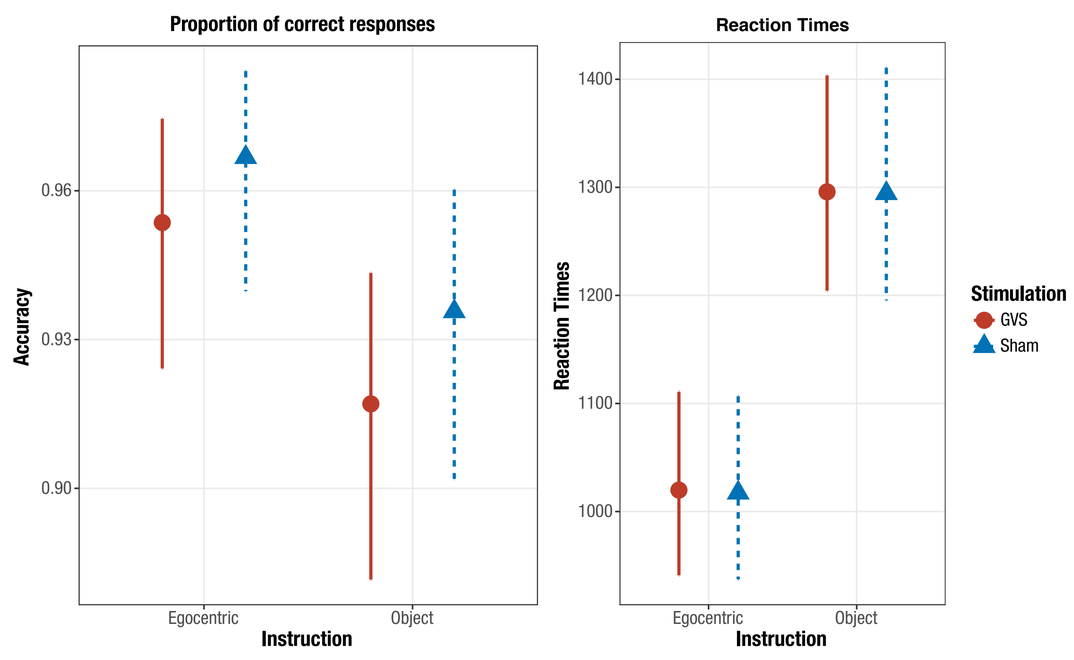


Fig.3: On the left, participants' proportion of correct responses for the different conditions. The analysis revealed a meaningful influence of the rotation instruction on the proportion of correct responses, but no influence of stimulation and no interaction. **On the right**, the results of the reaction times analysis. The analysis revealed faster reaction times in the egocentric rotation conditions, but no effect of GVS and no interaction.

Acknowledgment

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