Meta-analytical definition and functional connectivity of the human vestibular cortex

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Abstract

Contrary to most other sensory systems, no consensus has been reached within the scientific community about the exact locations and functions of human cortical areas processing vestibular information. Metaanalytical modelling using activation likelihood estimation (ALE) for the integration of neuroimaging results has already been successfully applied to several distinct tasks, thereby revealing the cortical localization of cognitive functions. We used the same algorithm and technique with all available and suitable PET and fMRI studies employing a vestibular stimulus. Most consistently across 28 experiments vestibular stimuli evoked activity in the right hemispheric parietal opercular area OP 2 implicating it as the core region for vestibular processing. Furthermore, we took our primary results as a seeding point and fed them into a functional connectivity analysis based on resting-state oscillations in 100 healthy subjects. This subsequent calculation confirmed direct connections of the area OP 2 with every other region found in the meta-analysis, in particular temporo-parietal regions, premotor cortex, and the midcingulate gyrus. Thus revealing a joint vestibular network in accordance with a concept from animal literature termed the *inner vestibular circle*. Moreover, there was also a significant vestibular connectivity overlap with frontal but not parietal cortical centres responsible for the generation of saccadic eye movements. This was shown in an additional ocular motor meta-analysis.

We conclude that the cytoarchitectonic area OP 2 in the parietal operculum, embedded in a joint vestibular network, should be the primary candidate for the human vestibular cortex. This area may represent the human homologue to the vestibular area *PIVC* as proposed by Guldin and Grüsser in non-human primates.

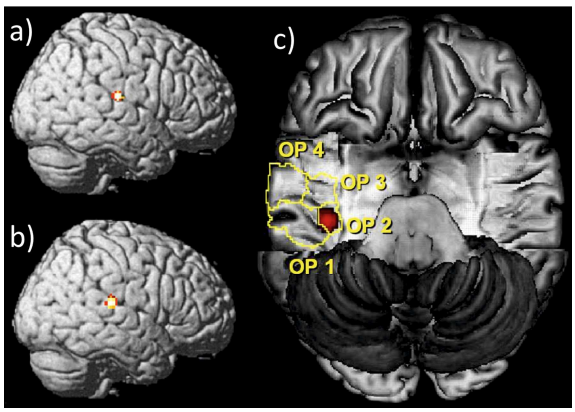

Figure: **a)** Significant overlap between regions showing convergent activation following caloric and non-caloric stimulation (both thresholded at a cluster-level $p < 0.05$) was found only in a single region on the right posterior parietal operculum. The result is shown as a projection onto the surface of the temporo-parietal cortex. **b)** Significant overlap between regions showing convergent activation following left and right unilateral cold caloric stimulation, respectively, (both thresholded at a cluster-level $p < 0.05$) was also found only in a single region on the right posterior parietal operculum. **c)** Comparison of the region identified in both conjunction analyses with the cytoarchitectonic parcellation of the human parietal operculum in a caudo-cranial view. The most likely location of the human PIVC corresponds to histologically defined area OP 2 (85% volume overlap, probability at local maximum 70%).

Keywords: vestibular cortex, ALE, OP2, functional connectivity

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