Cortical Activation in Tinnitus Patients studied with fMRI

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Purpose. To study underlying cerebral processes probably related to tinnitus by comparing fMRI activation of a frequency discrimination task in tinnitus patients and age-matched healthy volunteers in a study approved by our local ethics review board.

Methods. Seventeen tinnitus patients (11f, 6 m, 22-53 (38.8) yo) and nine healthy, normally hearing volunteers (6 f, 3 m, 21-53 (35.2) yo) were scanned with fMRI using a block design. Tones were played as 50 ms beeps at a rate of 5 per second at three different frequencies, 3 kHz as well as 2 % above and below this center frequency. Each frequency was presented as block of 32 sec pseudo-randomized with silence blocks of identical length. Subjects' attention was directed to the tones by the task of discriminating tones by frequency. On a Siemens Magnetom Vision MR scanner at 1.5 T, 37 slices (3 mm + 0.6 mm gap) covering the whole brain were acquired using a single-shot EPI sequence with cartesian readout at 64x64 matrix, FoV 230 mm and TE/TA/FA 66/4000 ms / 90°.
Data processing and analysis was performed with SPM 99. The contrast 'all frequencies minus silence' was calculated for each subject and thresholded at p = 0.05 corrected. A group analysis was performed to visualize main effects of both groups (p = 0.0001 uncorrected) as well as differential effects between groups (p = 0.001 uncorrected).

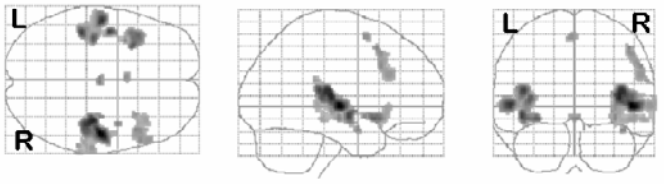

Fig. 1 Main effect of patients. p = 0.0001 not corrected for multiple comparisons. Secondary auditory cortex (AII) and left supplementary motor area (SMA) activation.

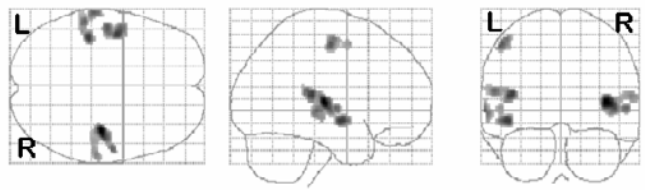

Fig. 2 Main effect of controls. p = 0.0001 not corrected for multiple comparisons. AI and AII and right SMA activation and border to anterior cingulated gyrus (ACC).

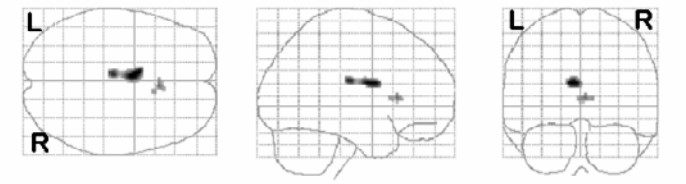

Fig. 3 Differential effect of patients - controls. p = 0.001 not corrected for multiple comparisons. Activation of caudate nucleus.

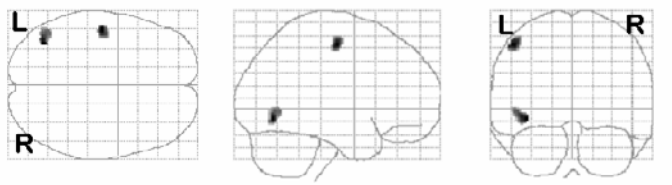

Fig. 4 Differential effect controls minus patients. p = 0.001 not corrected for multiple comparisons. Left primary sensory Area SI and fusiform gyrus (BA 19) activation.

Results. Subjects of both groups showed activation not only in primary and secondary auditory cortex but also in frontal cortical areas (Brodman Area (BA) 6 and 3). For single subjects, this was more obvious in patients rather than in controls (not shown). This effect was also seen in the patients' group analysis (Fig. 1) where activation is revealed in the right middle frontal gyrus, namely BA 9, of the dorso-lateral prefrontal cortex (DLPFC). Frontal activation in controls was not significant in the group analysis (Fig. 2), where besides the secondary auditory areas only the left postcentral gyrus was activated. Analysis of group differences revealed activation of subcortical areas corresponding to caudate head and body as well as the red nucleus and inferior colliculus to be more pronounced in patients than in healthy controls (Fig. 3). The opposite contrast demonstrates higher activation levels in controls compared to patients mainly in two left-hemispheric regions (Fig. 4): a parietal region corresponding to BA 3 or primary sensory cortex SI, and an occipito-temporal region, corresponding to BA 19, a secondary optical area.

Discussion. Brain activation in tinnitus patients and controls was studied by presenting intermittent tones at different frequencies. Frontal activation was seen in almost all subjects, predominantly in tinnitus patients, at variable t-values. For patients, this persisted in the group analysis. DLPFC activation as seen in the patient group corresponds with previous PET findings in tinnitus patients [1]. Despite of the broad variability in the clinical manifestation of tinnitus in our patient group – some had monaural, other binaural tinnitus; some presented tinnitus at certain isolated frequencies, others had a broad-band tinnitus – we were able to reveal group differences between patients and controls which was not possible previously [2].

References. 1. Lockwood AH et al.: The functional anatomy of gaze-evoked tinnitus and sustained lateral gaze. Neurology 2001;56:472– 480
2. Wunderlich et al.: Tinnitus-related cortical regions evaluated by fMRI. Proc. ISMRM 11 (2004), 2544