Cortical Activation of a Distraction Task in Tinnitus Patients and Controls studied with fMRI

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Purpose. To study sound suppression strategies in tinnitus patients and age-matched healthy volunteers by fMRI activation of a distraction task in a study approved by our local ethics review board.

Methods. Six tinnitus patients (3f, 3 m, 20-41 (28.7) yo) and six healthy, normally hearing volunteers (2 f, 4 m, 22-41 (28.5) yo), all right handed, were scanned with fMRI. A language task, the word pair paradigm, was presented in blocks of 28 s duration with appropriate advice to direct the attention of the subjects to this visually presented task. Simultaneously, patients were acoustically stimulated in a distracting manner by tones played as 50 ms beeps at a rate of 5 per second at three different pitches, at 2 kHz as well as 2 % above and below this center frequency. Each pitch was presented as block of 32 sec, and blocks of different tones were pseudorandomized in order together with silence blocks of identical length. 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°. The run length was 14 min 56 sec.
Data processing and analysis was performed with SPM. The study design allowed for separate analysis of the language task and the distracting auditory stimulation, resp. A group analysis was performed to visualize main effects of both groups ($p < 0.001$ uncorrected) as well as differential effects between groups ($p < 0.001$ uncorrected).

Results. In the results of the language task, subjects of both groups showed activation of visual areas, DLPFC (dorsolateral prefrontal cortex) as well as Broca's area (Fig. 1 and 2). Evaluation of group differences gives no significant results (not shown). Analyzing the distracting tones yields auditory areas, mainly of the left hemisphere, in both groups (Fig. 3 and 4). A higher z-score (patients 4.1, controls 3.8) and larger clusters (patients 273, controls 47 voxels) of auditory activation are detectable in tinnitus patients when considering the distracting tones. This can be verified in the analysis of the group difference patients minus controls, which shows Brodman Area (BA) 21 (cf. Fig.5). The reverse contrast controls minus patients fails to display significant activation (not shown).

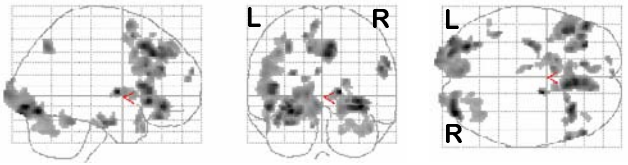

Fig. 1 Patient group analysis of the language paradigm. Visual cortex, DLPFC and Broca's area activation.

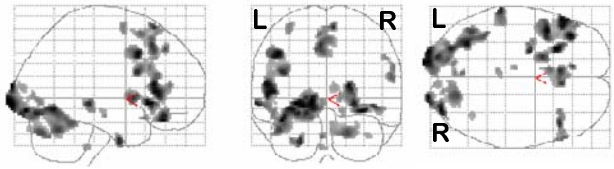

Fig. 2 Control group analysis of the language paradigm. Activation comparable to Fig. 1.

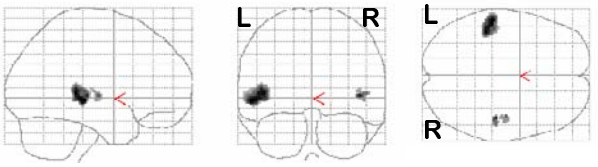

Fig. 3 Patient group analysis of distracting tones. Bilateral auditory activation (mainly AI, AII and right anterior insula).

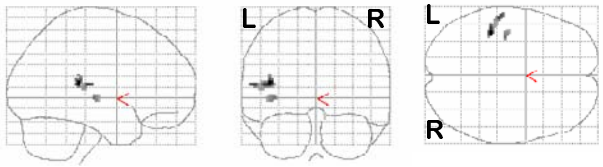

Fig. 4 Control group analysis of distracting tones. Left-sided auditory activation (mainly AI).

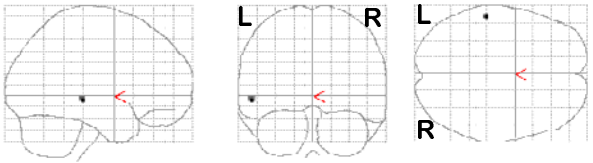

Fig. 5 Differential analysis patients minus controls. Left-sided auditory activation (left middle temporal gyrus, BA 21).

Discussion. Brain activation in tinnitus patients and controls were investigated in a distraction task combined from a visual presented language paradigm and intermitting beeps presented simultaneously in order to distract subjects. Both groups show comparable activation in the language task, indicating similar processing strategies for visual input. Evaluation of the distracting sound stimuli reveals markedly higher activated auditory areas in patients, which can be interpreted as an disability of suppressing currently not meaningful auditory input. BA 21, which was shown in the group difference, has been activated also in studies on acoustical hallucinations [1].This might play a role in the development of tinnitus. With the described combined visual and auditory paradigm, we were able to detect a difference in the ability of sound suppression which was not possible in fMRI studies using auditory stimulation alone [2].

References. 1. Bentaleb et al. Cerebral activity associated with audit. verb. hallucinations … J Psychiatry Neurosci. 2002 27(2):110-5
2. Wunderlich et al.: Cortical Activation in Tinnitus Patients studied with fMRI. Proc. ISMRM 13 (2006), 319