Deactivation in Tinnitus patients and Controls during a Tone Discrimination Task studied with fMRI

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Introduction. Chronic subjective tinnitus is defined as an individual sound sensation in the absence of a real physical sound stimulus. It is a widespread disease with great impact - approximately 1% of individuals experience their tinnitus so annoying that they receive various treatments[1,2]. Imaging studies with positron emission tomography (PET) and functional magnetic resonance (fMRI) have identified various active brain areas in patients with chronic subjective tinnitus. However, it remains unclear which areas are relevant for tinnitus generation. A recently published study[3] hinted at deactivation during tone presentation in healthy controls but not in tinnitus patients. Thus, in this complementary analysis we focused on deactivation patterns which may play a crucial role in tinnitus.

Methods. Six patients with chronic subjective tinnitus and six age-matched healthy, normal hearing volunteers were scanned with fMRI using a block design. Tones at 2940, 3000 and 3060 Hz were presented as 50 ms beeps at a rate of 5 per second over a sound proven headphone above MR noise level. The three frequencies and silence periods were each presented for 32 s in pseudorandomized order with six incidences per condition. The attention of the subjects was attracted to the tones by asking for button press when a change in frequency was detected. On a Siemens Magnetom Vision MR scanner at 1.5 T 37 slices per volume were acquired covering the whole brain using a single-shot EPI sequence with Cartesian readout at TE/TA/FA 66/4000 ms / 90° and a bandwidth of 2080 Hz/pixel. Data preprocessing and analysis was performed with SPM (http://www.fil.ion.ucl.ac.uk/spm). The contrast between conditions 'no stimulation' greater 'all tones', which reveals deactivation during tone discrimination, was calculated within-group for controls and patients as well as for differences between groups. Voxels with $p < 0.001$ not corrected for multiple comparisons were regarded significant, cluster threshold was set to 10 contiguous voxels. Brain areas coinciding with significant clusters were identified with the Talairach daemon[4].

Results. Besides the medial frontal gyrus, the left precuneus and the left angular gyrus, deactivation in controls was detected in the caudate nucleus (CN) and the right superior frontal gyrus (SFG) (Fig. 1). In contrast, patients showed no significant deactivation (data not shown). With regard to the between-group comparisons, no areas were detected where patients significantly deactivated more than controls (data not shown). The reverse contrast, namely more pronounced deactivations in controls than in patients, revealed deactivation of the left caudate nucleus, the left posterior cingulate gyrus (PCG) and the right SFG (Fig. 2).

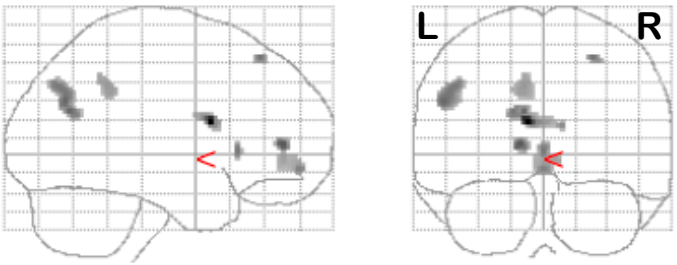

Fig. 1 Deactivation observed during the tone discrimination task in the control group showing caudate body, PCG and right SFG. No significant deactivation was found in patients (data not shown).

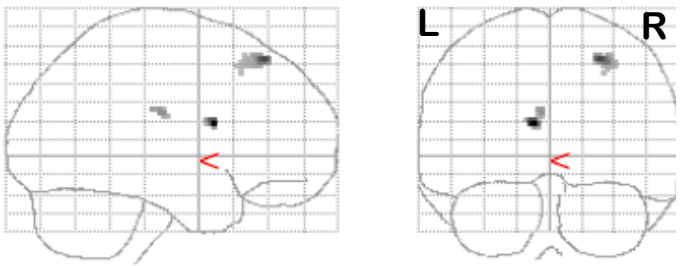

Fig. 2 Deactivation was more pronounced in controls compared to patients in left CN, left PCG and right SFG. No deactivation was significantly stronger in patients than controls (data not shown).

Discussion. In the current study we show that in the control group caudate body, PCG and right SFG were deactivated during the tone discrimination task compared to conditions without tone presentation. The phenomenon of task related deactivation can be explained by activation of certain areas during rest in healthy subjects which is not observed in tinnitus patients. Activation of several areas including the CG during rest and deactivation of these areas during cognitive performance in healthy subjects has been described previously by Tomasi[5] et al. These authors suggest that the task-dependent balance of activation and deactivation might allow maximization of resources for the activated network. Our study shows missing deactivation of certain areas in tinnitus patients, possibly leading to impaired ability to focus on cognitive tasks. This finding is in line with observations that tinnitus patients show reduced ability to suppress disturbing sounds while performing a cognitive task[6]. In contrast to tinnitus patients, persons with compulsive-obsessive disorder show hyperactivity of the orbitofrontal cortex, the anterior cingulate cortex, and the head of the caudate nucleus compared to controls during rest[7]. This might indicate differential roles of these areas in different neuropsychiatric conditions.

References

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