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CNS BOLD fMRI effects of sham-controlled transcutaneous electrical nerve stimulation in the left outer auditory canal - a pilot study.

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Abstract

BACKGROUND: It has recently been shown that electrical **stimulation** of sensory afferents within the outer auditory canal may facilitate a transcutaneous form of central nervous system **stimulation**. **Functional magnetic resonance** imaging (fMRI) blood oxygenation level dependent (BOLD) effects in limbic and temporal structures have been detected in two independent studies. In the present study, we investigated BOLD fMRI effects in response to transcutaneous electrical **stimulation** of two different zones in the left outer auditory canal. It is hypothesized that different central nervous system (CNS) activation patterns might help to localize and specifically stimulate **auricular** cutaneous vagal afferents.

METHODOLOGY: 16 healthy subjects aged between 20 and 37 years were divided into two groups. 8 subjects were stimulated in the anterior wall, the other 8 persons received transcutaneous vagus nervous **stimulation** (tVNS) at the posterior side of their left outer auditory canal. For sham control, both groups were also stimulated in an alternating manner on their corresponding ear lobe, which is generally known to be free of cutaneous vagal innervation. **Functional** MR data from the cortex and brain stem level were collected and a group analysis was performed.

RESULTS: In most cortical areas, BOLD changes were in the opposite direction when comparing anterior vs. posterior **stimulation** of the left auditory canal. The only exception was in the insular cortex, where both **stimulation** types evoked positive BOLD changes. Prominent decreases of the BOLD signals were detected in the parahippocampal gyrus, posterior cingulate cortex and right thalamus (pulvinar) following anterior **stimulation**. In subcortical areas at brain stem level, a stronger BOLD decrease as compared with sham **stimulation** was found in the locus coeruleus and the solitary tract only during **stimulation** of the anterior part of the auditory canal.

CONCLUSIONS: The results of the study are in line with previous fMRI studies showing robust

BOLD signal decreases in limbic structures and the brain stem during electrical **stimulation** of the left anterior auditory canal. BOLD signal decreases in the area of the nuclei of the vagus nerve may indicate an effective **stimulation** of vagal afferences. In contrast, **stimulation** at the posterior wall seems to lead to unspecific changes of the BOLD signal within the solitary tract, which is a key relay station of vagal neurotransmission. The results of the study show promise for a specific novel method of cranial nerve **stimulation** and provide a basis for further developments and applications of non-invasive transcutaneous vagus **stimulation** in psychiatric patients.

KEYWORDS: Anti-depressant; BOLD; Brain **stimulation**; Non-invasive; Psychiatric; TENS; Transcutaneous vagus nerve **stimulation**; VNS; Vagus nerve **stimulation**; fMRI; t-VNS; tVNS

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