ELECTRICAL BRAIN STIMULATION FOR TINNITUS

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Introduction

Based on initial animal studies tinnitus is proposed to be an auditory phantom phenomenon associated with a synchronized hyperactivity and reorganization of the two auditory pathways (lemniscal and extralemniscal) all the way up to the auditory cortex. Furthermore, functional imaging techniques (magnetic source imaging) in humans, have demonstrated a correlation between tinnitus strength and the amount of reorganization of the primary cortex. This synchronized hyperactivity associated with tinnitus has been verified in humans and a pathophysiological mechanism has been proposed : thalamocortical dysrhythmia. The basic idea suggests that decreased auditory stimulation results in a decreased thalamic firing rate, decreasing lateral inhibition. Consequently the surrounding area becomes hyperactive, firing at gamma band rates, which is transmitted to the auditory cortex. The gamma band electrical auditory cortex activity is a condition sine qua non for auditory consciousness, and thus tinnitus. Synchronization of this gamma band activity could possibly induce topographical reorganization due to Hebbian mechanisms (cell that fire together wire together), explaining the association between synchronized hyperactivity and reorganization.

Therefore it seems logical to try and modify this tinnitus related auditory cortex reorganization/hyperactivity in an attempt to suppress the tinnitus.

Methods

The method used for continuous tinnitus suppression consists of 3 phases

1. localize the tinnitus generating area in the auditory cortex by functional imaging
2. attempt to suppress the tinnitus non-invasively by TMS targeting the hotspot as demonstrated on functional imaging
3. surgical implantation of electrodes on same hotspot

It has been shown that the fMRI BOLD effect correlates to event related synchronized gamma band activity, suggesting that fMRI could become a very meaningful technique to investigate tinnitus (when controlling for MRI generated sound interference).

Using fMRI guided neuronavigated transcranial magnetic stimulation (TMS), a technique that is capable of modulating cortical activity non invasively, an attempt can be made to suppress tinnitus.

If TMS is capable of suppression of tinnitus, the effect could be maintained by implantation of electrodes at the area of signal abnormality on the auditory cortex.

The first results in these patients demonstrate a statistically significant tinnitus suppression for unilateral pure tone tinnitus, without suppressing white or narrow band noise.
Using a recently developed novel stimulation paradigm, white noise can also be suppressed in a statistically significant way on TMS, and the first electrical stimulations on implanted electrodes seem equally successful.

Conclusion
Auditory cortex stimulation could become a physiologically based treatment for a selected group of unilateral tinnitus patients. Now that white noise also seems to fall within the reach of auditory cortex stimulation, the predominant question remains what the pathophysiological difference is between uni- and bilateral tinnitus.