

High frequency treatment of tinnitus with potentially wearable technology.

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Tinnitus is a perception without an auditory sensation. Generally it is the after result of acoustic trauma and becomes more centrally mediated over time. It is precisely the central component that lends itself difficult to treat. In the case of the severe disabling type, it is as if tinnitus hijacks the brain activating temporal, parietal and frontal lobes, many nuclei of the thalamus and brain stem plus the cerebellum. How can tinnitus, defined operationally as a low volume and restricted high pitch spectrum entity, have such comprehensive psychological affects as annoyance, distress, depression and frustration? The answer may lay in long term induced auditory brain changes including increased spontaneous firing rate, increased synchronization and neuroreprogramming that prompt maladaptive emotional changes. Norena and Eggermont, (2005) demonstrated moderate high frequency stimulation reduced the auditory effects, prevented cortical reprogramming and minimized hearing loss. Low frequency exposure had no such effects. Logically high frequency hearing aids were evaluated in regard to this tinnitus protective effect, but the effort was unsuccessful (Moffat et al., 2009). In contrast, high frequency stimulation, covering the tinnitus spectrum and beyond was effective in producing dramatic improvement in tinnitus severity, lowering minimal masking levels and improving hearing in the tinnitus spectrum. The stimulation is by bone conduction and delivered at 10 dB SL, not as a masker, but as high frequency perception that interacts with tinnitus. Although this initial technology is no longer available, a new version is being developed that will mimic a hearing aid with a frequency response from 2-20 kHz. Bone conduction delivery technology is retained (having FDA pre-market approval) and is coupled to a high speech modulator and a tunable (to the listener) swept frequency carrier(s). A desk top version has proved successful in increasing speech intelligibility in noise and functionally capable of using a television or other audio mobile devices as input to produce high frequency therapeutic stimulation. This technology has a marked advantage over the previous system in that therapy is processed sound from interest engaging sources. Listening to a processed sport broadcast would provide more than sufficient daily stimulation. Applying gamification, use of play mechanics for tinnitus treatment, opens up numerous audio patterns from personal multimedia as inputs to this tinnitus treatment system. The treatment emphasis is on reducing the auditory effects of severe tinnitus, early after exposure or of tinnitus that is long term in duration; and, by so doing, fading abnormal limbic effects. Limbic habituation is likely to be a slower process; however, the presence of

lowered tinnitus severity, lowered MML and improved high frequency hearing as a consequence of therapy brings some relief. Even with successful tinnitus treatment, tinnitus annoyance may remain static, suggesting the need for on-going behavioral co-support.