



Notched Sound Therapy as a Treatment for Tinnitus: A Primer for Hearing Health Professionals

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About the Author

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Tinnitus is a common hearing-related problem that leads patients to seek help from hearing health professionals. It's an extremely prevalent problem, affecting millions of people worldwide.¹ However, only a small fraction of tinnitus sufferers become distressed enough to seek treatment for this problem. Evidence suggests that most people are able to habituate to the tinnitus tone, which ceases to become bothersome to the patient. Those who don't, however, can be severely negatively affected, and may have underlying vulnerabilities that predispose them to become psychologically distressed by tinnitus.

The majority of individuals with tinnitus

have acquired it from hearing loss, although there is a long list of possible causes. The initial evaluation of tinnitus should always determine whether it is a symptom of serious disease requiring medical intervention (for example, an acoustic neuroma growing in the VIII cranial nerve or low brain stem). However, the most common variant of tinnitus is "sensorineural" tinnitus – the consequence of a *neuroplastic* response in the auditory system to a loss of input from the cochlea to the auditory cortex. It's this subtype that the vast majority of audiologists deal with.

I first experienced tinnitus as a medical student, and in a desperate search for answers, I had a difficult time making sense of it all. It was doubly difficult because, as a person in acute

distress, you *want* to believe all the positive results you read. I eventually stumbled upon Notched Sound Therapy through a professor at my university, which provided me with some acute relief. Fortunately, over the next couple of months I habituated to my tinnitus and didn't really need any more ongoing therapy, but I realized that there was a gap in the market and decided to start a small business to provide this service to others.

"Notched Sound Therapy" is a term derived from how the therapy is made – you take unprocessed audio input such as music or white noise, and "notch out" sound energy at and around the tinnitus frequency of the user. Notched Sound Therapy is audio sound input that has been processed with a "notch" centred

at the frequency of a patient's tinnitus.² In this context, a "notch" is made in the audio by a computer algorithm that removes the sound energy at and around the patient's tinnitus frequency. Different researchers have used different notch widths, ranging from one octave to one equivalent rectangular bandwidth. The effects of Notched White Noise has been studied in a randomized control trial (where subjects were randomly assigned to placebo and treatment groups). The effects of Notched Music has been studied in a group of small pseudo-randomized control trials (where the subjects were not randomly assigned to placebo and treatment groups). Both studies have demonstrated that listening to Notched Sound Therapy can directly lower the volume of tinnitus, and in doing so, reduce the psychological annoyance caused by the tinnitus tone.²⁻⁴ The experiments ran with treatment cycles of twelve month's duration, however, significant reductions in tinnitus volume can be seen as early as one week into therapy (provided that it is intense in duration).⁴

The Notched Sound Therapy approach is limited to people who have tinnitus tones that can be successfully localized with either our on-line tuner or with the aid of an audiologist. The mechanism of action isn't understood, but it's thought to occur through strengthening lateral inhibition networks between healthy auditory neurons and the aberrant neurons that spontaneously fire, causing the perception of tinnitus. Thus, a combination of lateral inhibition and subsequent changes in the auditory cortex via cortical plasticity appear to be implicated.² Selectively stimulating the auditory neurons that don't produce the tinnitus frequency appears to laterally inhibit the auditory neurons

that do produce the tinnitus frequency.² Sustained lateral inhibition rewires the connections between neurons in the auditory cortex so that the baseline level of inhibition increases (even when users aren't listening to the music).² Therefore the tinnitus volume decreases.

One of the advantages of Notched Sound Therapy is that the approach has been successfully replicated by two groups of researchers. Replication is one of the most important concepts in experimental science. The basic idea is that if an experiment discovers a treatment to be truly effective, then this finding should be able to be generalized (replicated) elsewhere in the world.

The original research on Notched Sound therapy came out of Germany and the research group of Dr. Christo Pantev. Subsequently, additional research from an analogous (but not identical) form of sound therapy came out of Italy. Whereas Dr. Pantev placed an auditory notch in music and provided this as therapy, the Italian researchers placed a "window" (which, functionally, was a notch) into broadband noise (which sounds like static). <http://www.tinnitusjournal.com/imagebank/pdf/v15n1a05.pdf>. Both experimental groups found a positive treatment effect, sometimes large, in their participants. This example of cross verification is why I believe that, for some people, Notched Sound Therapy does indeed work.

Again, the claims of efficacy around Notched Sound Therapy should be modest. It works for some people, some of the time, and seems to provide a moderate effect in the people that it does help. We have published our internal results here on our blog (choppy and low quality though the

data may be, it's better than nothing). <http://www.audionotch.com/blog/tinnitus/more-on-tinnitus-pitch-matching-a-study-of-interest/>

Notched Sound Therapy represents a new approach to sound therapy for tinnitus. It has two virtues: (1) it has been independently researched with positive therapeutic results, by two different European research groups (only one of which has attempted to commercialize their therapy afterwards), and (2) it is available at low cost to patients via third party proprietors.

HOW IT WORKS

Notched Sound Therapy takes place in three steps.³ In step one, patients determine the frequency of their tinnitus. This can be done in one of two ways: either with the use of a *web-based tinnitus tuner*, <http://www.audionotch.com/app/tune/> or alternatively, inside of an audiology clinic. In step two, patients choose the audio they wish to have "notched," which includes options ranging from music to white noise.^{2,3} The sound is then "notched" by a special software algorithm. In step three, patients listen to their Tailor-Made Notched Sound Therapy.² This can be done with any device capable of playing MP3 music files. *The lack of a proprietary device is what allows the cost of Notched Sound Therapy to be dramatically lower than its competitors.* After months of listening for several hours per day, a patient's tinnitus volume decreases.³ Again, although the exact mechanism of action is unknown, researchers believe that the therapy utilized cortical neuroplasticity to reduce the spontaneous firing of the neurons responsible for the tinnitus percept by strengthening

existing networks of lateral inhibition from undamaged cochlear hair cells.²

CHALLENGES FOR PARTNERING AUDIOLOGISTS

Determining a patient's tinnitus frequency has classically proven to be of variable difficulty. Patients have a hard time determining the frequency of their tinnitus, and often provide varying readings with little validity. Research has shown that there are two sub-groups of patients – *about 50% can reliably determine their tinnitus frequency, and about 50% cannot.* <http://www.audionotch.com/blog/tinnitus/more-on-tinnitus-pitch-matching-a-study-of-interest/>. In summary, tuning accuracy is critical for the success of notched sound therapy, as the notch must align with the actual tinnitus frequency (there is, however, some margin for error). In our experience, patients

prefer to have their tinnitus frequency detected by an audiologist, instead of using web-based software to do so.

Our web-based service is AudioNotch, but we also have an audiologist partnership program set up under a different brand: Tinnitus Treater. Details are available here on the Tinnitus Treater FAQ for clinics interested in a partnership. <http://www.tinnitustreater.com/audiologists>

THE STATE OF THE RESEARCH

A critical appraisal of the research on Notched Sound Therapy shows that, although encouraging, the studies suffered from multiple limitations, and more work needs to be done in this area to draw firm conclusions. More studies with larger sample sizes need to be done, and long-term follow-up studies must be performed to determine if the effect

of the therapy persists. However, for patients approaching audiologists and other hearing health professionals, it represents a reasonable treatment option that can be recommended in light of provisional scientific support. For those of you who are interested, I've written a commentary on a critical review of the research, which is available here. <http://thehearingblog.com/archives/2094>

REFERENCES

1. Eggermont JJ and Roberts LE. The neuroscience of tinnitus. *Trends Neurosci* 2004;27:676–82.
2. Okamoto H, Stracke H, Stoll W, Pantev C. Listening to tailor-made notched music reduces tinnitus loudness and tinnitus-related auditory cortex activity. *Proc Natl Acad Sci U S A* 2010;107:1207–10.
3. Lugli M, Romani R, Ponzi S, Bacciu S, Parmigiani S. The windowed sound therapy: a new empirical approach for an effective personalized treatment of tinnitus. *Int Tinnitus J* 2009;15:51–61.
4. Teismann, H., Okamoto, H., Pantev, C. Short and intense tailor-made notched music training against tinnitus: The tinnitus frequency matters. *Plos ONE* 2011;6:1–8.

