Software for personalised notched music training (TMNMT) using Indian classical music for persons with tinnitus

Tinnitus is a chronic condition of the ear with significant impact on quality of life. Subjective tinnitus is a sound perceived by the patient alone; it may be a buzzing, humming, crackling or noise. Tinnitus affects around 5–20% of world population; incidence increases with age. While a definitive cure is not available for tinnitus, various modalities of treatment such as medications, acupuncture, tinnitus retaining therapy, sound therapy, neuromodulation, masking, cognitive behavioural therapy, progressive tinnitus management have been described. Customised acoustic therapy is an emerging treatment for tinnitus. The theoretical mode of action is to directly target the implicated neural pathways. The individual tinnitus frequency of the patients is determined and a precisely matched narrow band sound/notched music is generated. Through repetitiously listening to this generated treatment sound, culprit neural pathways are stimulated and theoretically desynchronise. This induces downregulation of hyperactive pathways and reduces the tinnitus sensation. The theory of targeted neural excitation in treating tinnitus is supportive of neural inhibition as an acoustic mechanism in its origin [6].

Lately, a new approach using tailor-made notched music therapy (TMNMT) has been described that could significantly reduce tinnitus loudness and tinnitus-related auditory cortex activity. TMNMT does not provide any afferent input to the auditory cortex neurons that are activated in response to the tinnitus frequency, but neighboring neurons are activated to inhibit the frequencies within the notch region via lateral inhibition. In order to enhance the lateral inhibition effect within the notch area corresponding to the tinnitus frequency, the music energy spectrum is processed in three steps. First, the amplitude of the music frequency spectrum in all frequency ranges is equalized by the redistribution of energy from low to high frequency ranges. This guarantees an equal energy spectrum below and above the frequency area suppressed by the notch filter. Second, a frequency band of half an octave's width centered at the tinnitus frequency is removed. Third, a width of three eighths of an octave on both sides of the notch frequency is increased by 20 dB to amplify the energy difference between the notch region and the edge frequency. [7]

a) Tinnitus matching – by audiologist to determine the person's tinnitus frequency. Frequency range 250Hz to 8kHz only enrolled in the study

b) **Test group - Notched Music Therapy (TMNMT)**

Notched music
- use playlist selected by the audiologist/ songs brought by the patients
- Only Instrumental music or with vocal?
- produce the notched music
- notched music transferred to the smartphones

c) **Control group – Tinnitus retraining therapy (TRT)**

Create narrowband noise (masking) and transfer to the smart phones ?

d) Listening to music/noise and log
- Participants asked to listen attentively and daily for at least 2 hours to the music at a comfortable volume using the app. Participants are asked to adjust the volume so that it is just audible and no louder than their existing tinnitus to create a distraction or masking effect.
- The app records the listening periods, song number and loudness level (?) in a log file
- Feedback questions

e) Software development
- GUI based software for the audiologist to generate notched music/white noise – enter patient specific parameters, select songs from playlist
- app on smartphone (Android?) to load files, select and play the files, log user data, collect feedback
- app to have a user mode and an audiologist mode.

Software Requirements

The software has two parts. One part is for the doctor to create music files, and the second part is for the user to listen to the files. A desktop application (DesktopAPP) will be created for the doctors and a mobile app (Android APP) is created for the users.

1. **Desktop APP**

   The software shall have the following UI options for the doctors

   1. Add music files to a list that further needs to be processed
   2. Select Notched Music therapy OR TRT
   3. Specify the frequency of Tinnitus and the attenuation level at the frequency of Tinnitus for NMT
   4. Specify the frequency of Tinnitus and the parameters of the narrow band noise for TRT
   5. Write the processed music files to the output database

2. **Android App**

   The software is going to play the audio files to the users and log the amount of listening time. The software shall have the following options

   i. Read the database coming from the Desktop and show the list to user
   ii. All UI characteristics of a music player - Play, Pause, Volume, FF, etc
   iii. Random access to any song
   iv. The song listening time from the app must be logged
   v. Collect a feedback from the user

Notes:

1. Only uncompressed music files are processed
2. Initially Instrumental music is being tested
3. Generally the bandwidth of the notch filter and narrowband noise is around 10% of the center frequency
4. Quality of the output files needs to be tested externally tested

(i) References

1. Therdphaothai, J., Atipas, S., Suvansit, K., Prakairungthong, S., Thongyai, K., Limviriyakul, S. (2021), *A Randomized, Controlled Trial of Notched Music Therapy for Tinnitus Patients*, The journal of international advanced otology, 17(3), 221–227. https://doi.org/10.5152/iao.2021.9385
2. Engelke, M., Simões, J., Vogel, C., Schoisswohl, S., Schecklmann, M., Wölflick, S., Pryss, R., Probst, T., Langguth, B., & Schlee, W. (2023), *Pilot study of a smartphone-based tinnitus therapy using structured counseling and sound therapy: A multiple-baseline design with ecological momentary assessment*, PLOS digital health, 2(1), e0000183. https://doi.org/10.1371/journal.pdig.0000183
3. Kim, S. Y., Chang, M. Y., Hong, M., Yoo, S. G., Oh, D., & Park, M. K. (2017). *Tinnitus therapy using tailor-made notched music delivered via a smartphone application and Ginko combined treatment: A pilot study*, Auris, nasus, larynx, 44(5), 528–533. https://doi.org/10.1016/j.anl.2016.11.003

4. Tang, D., Wang, K., Ye, Z., Gu, D., Ye, L., Sun, S., & Li, H. (2022). *The Fudan Tinnitus Relieving System (FTRS): The initial results of a smartphone application for tinnitus management and treatment*, Internet interventions, 29, 100564. https://doi.org/10.1016/j.invent.2022.100564
5. Suh, M. W., Park, M. K., Kim, Y., & Kim, Y. H. (2023), *The Treatment Outcome of Smart Device-Based Tinnitus Retraining Therapy: Prospective Cohort Study*, JMIR mHealth and uHealth, 11, e38986. https://doi.org/10.2196/38986
6. Connell, J. T., Bassiouni, A., Harrison, E., Laden, S., O'Brien, S., Sahota, R., Carney, A. S., Foreman, A., Krishnan, S., & Hodge, J. C. (2023), *Customised acoustic therapy delivered through a web-based platform-An innovative approach to tinnitus treatment*. Clinical otolaryngology: official journal of ENT-UK ; official journal of Netherlands Society for Oto-Rhino-Laryngology & Cervico-Facial Surgery, 48(2), 226–234. https://doi.org/10.1111/coa.14027
7. Wang, H., Tang, D., Wu, Y., Zhou, L., & Sun, S. (2020), *The state of the art of sound therapy for subjective tinnitus in adults*. Therapeutic advances in chronic disease, 11, 2040622320956426. https://doi.org/10.1177/2040622320956426