

DECODING THE SECRETS OF TINNITUS: THE RINGING EAR

Abstract

Understanding and Functioning of Tinnitus: Insights into Categorization, Reasons, and Evaluation** Tinnitus, the perception of noise in the absence of external stimuli, has intrigued both medical experts and scholars. This article delves into the etymology of tinnitus, exploring technical terms such as “Tinnitus aurium,” “Acousma,” and “Leudet tinnitus.” Pioneers in this field, integrated Jack Vernon and Pawel J. The dispute extends to the neural mechanisms behind tinnitus, emphasizing the intricate relationship between the auditory, somatosensory, limbic and independent systems. The article details conditions similar to personal tinnitus, shedding light on otological, cardiovascular, metabolic, neurological and pharmacological components. An in-depth investigation of evaluation protocols, including comparison of pitch and loudness, provides insight into the clinical evaluation of tinnitus. The article then navigates through the intricate reasons for tinnitus, visually represented in a tree diagram. Psychological effects are catalogued in tables that describe the signs of emotional, interpersonal, and somatic distress associated with tinnitus. The multifaceted reasons for tinnitus are summarized in a comprehensive figure that shows a holistic perspective of the intricate network that contributes to this phenomenon. Moreover, this chapter discusses about the Tinnitus management employs diverse strategies, including advice, hearing aids, and innovative approaches like Neuromonics. Pharmacological options, non-invasive methods like Transcutaneous Vagus Nerve Stimulation, and alternative therapies contribute to a multifaceted approach.

Keywords: Tinnitus, Somatosensory, Transcutaneous Vagus, Acousma.

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I. INTRODUCTION

Tinnitus is a common and disruptive medical condition that is associated with factors like hearing loss, the use of ototoxic drugs, head injuries, and emotional challenges such as depression. When dealing with tinnitus, it's crucial to consider both potential ear-related problems and the potential coexistence of anxiety and depression.

II. TECHNICAL TERMS

- *Tinnitus aurium* – from the Latin meaning “jingling ear”
- *Acousma* – from the Greek meaning “a thing heard”
- *Tinnitus cerebri* – (Latin: cerebrum or brain) head noises
- *Arterial tinnitus* – produced by disturbances in blood flow in arteries passing through middle ear
- *Paracusia imaginaria* – Imaginated sound
- *Leudet's tinnitus* – spasmodic clicking sound from muscles that control ET opening.

III. PIONEERS IN THE FIELD OF TINNITUS

- American father of tinnitus – Jack Vernon
- British father of tinnitus – Ross R.A. Coles
- Father of neurophysiological model of tinnitus – Pawel J. Jastreboff.

Many people experience the sensation of hearing sounds in their ears or head, often referred to as tinnitus, especially after being in quiet surroundings or exposing themselves to loud music. The characteristics of tinnitus, its root causes, and its effects on individuals differ widely. Tinnitus can stem from the auditory system or para-auditory structures, which could offer clues about underlying health issues. Its existence can have negative impacts on both individuals and their families, resulting in social and psychological difficulties (Davis & El Rafeie, 2000).

Somatosound, also known as somatic or somatosensory tinnitus, involves perceiving sound without external auditory triggers. It arises solely from the central nervous system's activity, without any mechanical or vibratory actions in the cochlea. In simpler words, somatosound refers to hearing sounds that originate from non-auditory parts of the body.

The relationship between somatosound and tinnitus lies in the processing of sensory information within our brain. The auditory system and the somatosensory system are intimately linked, sharing neural pathways in the brain. This implies that signals originating from non-auditory structures like muscles, blood vessels, or nerves can impact how the auditory system interprets sound. Jastreboff's 1995 definition of somatosound denotes the perception of sound arising solely from central nervous system activity, unrelated to any mechanical actions within the cochlea and not prompted by external stimuli.

However, if there is a vibratory element within the cochlea contributing to sound perception, it is termed somatosound, as outlined by Jastreboff & Jastreboff in 2003.

The description of somatosound within the tinnitus definition is seen as misleading for two main reasons:

1. Somatosound actually refers to genuine sounds transmitted through the normal cochlear process, capable of being masked in a frequency-specific manner.
2. Somatosound can be pinpointed to a particular location and might respond well to medical or surgical interventions.

Tinnitus perception is thought to arise from abnormal neuronal activity at a subcortical level in the auditory pathway, with the cortex having a predominantly passive role. Tinnitus perception is associated with irregular synchronization of auditory nerve activity and imbalanced function of Type I and Type II afferent fibers in the auditory system. Furthermore, tinnitus involves the recall of pattern recognition memory and connections with other systems, particularly the limbic and autonomic systems. This perspective suggests that tinnitus is not solely tied to a specific anatomical location, but rather involves various centers across the nervous system.

IV. INCIDENCE AND PREVALENCE

Research involving adults aged 48 to 92 years discovered that tinnitus was present in 8.2% of participants at the start of the study, and 5.7% experienced its onset over a 5-year period (Nondahl et al. 2002). The American Tinnitus Association (2004) reports that 50 million Americans encounter tinnitus, of whom 12 million actively seek medical help. A more severe form of the condition, severely affecting quality of life, is found in one million individuals.

V. CLASSIFICATION OF TINNITUS

Tinnitus can be classified based on different criteria:

1. Classification based on Site:

- **Conductive Tinnitus:** Occurs as a result of vibrations within the middle ear.
- **Sensorineural Tinnitus:** Arises from problems affecting the inner and outer hair cells, auditory nerves, and other sensory structures.
- **Central Tinnitus:** Develops due to abnormal processing within the central auditory pathways.

2. Classification Based on Duration:

- **Short-Duration Tinnitus:** Connected to issues in the middle ear.
- **Long-Duration Tinnitus:** Conditions such as Meniere's disease, palatal myoclonus, jugulotympanic paraganglioma, patent cochlear duct, ototoxicity and acoustic neuroma are illustrative instances of such medical disorders,.

3. Classification based on Symptoms:

Objective tinnitus generates audible sounds that a clinician can perceive. It can manifest as distinct noises such as blowing, breathing, rhythmic pulsations, or popping sounds. Conditions linked to objective tinnitus

encompass a patent Eustachian tube, cardiovascular issues (with pulsations synchronized to the heartbeat), tumors in the middle ear's blood vessels, and contractions of middle ear muscles. Compared to subjective tinnitus, objective tinnitus is less common.

Conversely, subjective tinnitus is the most common tinnitus form among patients. In this type, only the affected individual can hear the sound, making it impossible for a physician to detect. It is the most commonly experienced issue where only the patient perceives the tinnitus sound.

Conditions associated with Subjective tinnitus;

- **Otological Disorders:** Subjective tinnitus, which is experienced only by the affected individual and often coincides with sensorineural hearing loss, is the most common cause of tinnitus across all age groups (90%). In a study by Heller ME and Bergman MT published in the *Annals of Otolaryngology* in 1953, tinnitus was associated with various conditions, including:
 - Ear disorders such as otosclerosis, Meniere's Disease, and Lerimoyez's syndrome.
 - Issues affecting the auditory apparatus like pressure or neuritis, brain tumors, eighth nerve tumors, and aneurysms.
 - Different types of otitis media (acute, chronic, suppurative, and non-suppurative) and otitis interna (acute and chronic).
 - Hearing within the normal range but with a specific frequency defect.
 - Nasopharyngeal diseases including Eustachian tube salpingitis, sinusitis, pharyngitis, mucosal hypertrophy, hyperplasia, tumors, and lymphoid tissue infections.
 - Dental problems like malocclusion, temporomandibular joint issues, impaction, and infection.
 - Myositis affecting the cervical, pharyngeal, and tympanic areas.
 - Intoxication from substances like quinine, alcohol, salicylates, caffeine, tobacco, antileptic agents, streptomycin, and thyroid gland extracts.
 - Intoxication syndromes related to gastrointestinal issues and facial infections.
 - Allergic reactions.
 - Cardiovascular conditions including blood disorders, anemias, hypotension, vascular anomalies, arteriosclerosis, and heart disease.
 - Metabolic dysfunctions like thyroidism and water balance disturbances.
 - Trauma, both acute and chronic, particularly acoustic trauma.
 - Systemic fatigue.
 - Momentary tinnitus of spontaneous and idiopathic nature.
 - Impacted cerumen (earwax blockage).
 - Cervical constriction.
 - Psychosis.
 - Otic herpes.
 - Bell's palsy.
 - Trauma caused by foreign bodies in the ear.
 - Head injuries, concussions, and post-concussion syndrome.
 - Myringitis and hemorrhage affecting the tympanum (eardrum).

- **Cardio Vascular Problems:** A common occurrence among the older population group. Approximately 37% of tinnitus patients have reported cardiovascular issues. The causes may involve:
 - High blood pressure.
 - Anemia (where tinnitus is secondary to an increased heart rate and cardiovascular output, resulting in low-pitched sounds).
 - Extensive arteriosclerosis (low-pitched pulsating sound) - characterized by turbulence noise.
 - Changes in venous blood flow (resulting in a low-frequency soft hum).

- **Metabolic Disease:**
 - Tinnitus can be caused by diabetes and thyroid disorders.
 - Hyperthyroidism, which involves increased cardiac output, can lead to rushing or pulsatile tinnitus.
 - Abnormal cholesterol levels and hyperlipidemia are also potential causes.
 - Although rare, vitamin deficiency can be associated with tinnitus.

- **Neurological Disease:**
 - Tinnitus may result from head trauma, with an incidence of about 10%.
 - Conditions such as skull fracture or severe closed head injury can lead to tinnitus.
 - While rare, tinnitus can also be associated with meningitis and multiple sclerosis.

- **Pharmacological Factors:** Tinnitus can potentially be caused by various types of medications. Ototoxic drugs like aminoglycosides, aspirin, caffeine, and nicotine are known to induce tinnitus. Additionally, tinnitus can be associated with:
 - Anti-inflammatory drugs.
 - Antibiotics.
 - Sedatives and antidepressants.

4. Classification based on Severity:

- Mild tinnitus is typically perceived only in quiet surroundings or before bedtime. It is generally not highly bothersome, and the patient can easily divert their attention from the tinnitus by focusing on other stimuli.
- Moderate tinnitus is more pronounced and persists consistently. The patient is aware of the tinnitus when attempting to concentrate or trying to sleep.
- Severe tinnitus can incapacitate individuals to the point where they find it challenging to focus on anything other than the tinnitus itself.

5. **Classification based on Pathology:** Most individuals with regular hearing experience typical tinnitus, which lasts for under 5 minutes and happens less than once a week. Conversely, abnormal tinnitus, commonly found in individuals with hearing loss, persists for more than 5 minutes and occurs more than once a week.

6. Classification based on Site :

- Peripheral
- Central

7. Classification based on Etiology:

- Induced by noise exposure
- Endolymphatic hydrops
- Toxicity to ear by ototoxic medication
- Age related hearing loss
- Idiopathic

8. Classification Based on Duration:

- **Temporary Tinnitus:** Brief tinnitus episodes likely caused by temporary issues in the auditory system, such as exposure to loud noise or certain medications.
- **Permanent Tinnitus:** This type of tinnitus can be constant or intermittent, where the tinnitus recurs after disappearing for a period.

The classification of tinnitus based on duration indicates a wide range of tinnitus experiences, spanning from short instances (like temporary tinnitus after loud noise exposure or high aspirin dosage) to continuous occurrences. The commonly used benchmark is perceiving sound for at least five minutes to categorize it as tinnitus, yet this timeframe lacks significant theoretical or clinical relevance. Despite proposed tinnitus theories, the duration doesn't significantly impact the mechanisms behind tinnitus generation. Duration is just one aspect among several factors contributing to the distress associated with tinnitus.

VI. EFFECT OF TINNITUS

Table 1: Psychological Effects of Tinnitus: (Rubinstein & Erlandsson, 1991)

Emotional distress (Tyler & Baker, 1983)	Interpersonal Complaints	Somatic distress symptoms
Irritation, inconvenience, challenges in focusing and sleeping, feelings of sadness and hopelessness.	Misunderstanding, Negative effect on relationships	Pain in head & neck. Jaw muscle pain & Tension, dizziness, highly sensitive to sound.

Table 2: 3D of Tinnitus Complaint

Affective Aspect	Audiological	Intrusiveness
Melancholy, resentment, Restlessness, apprehension	Perception difficulties (Problem in listening to others during social gathering)	Focused continuously on ringing sensation in ear, not able to concentrate, Sleeping difficulty

VII. CAUSES OF TINNITUS

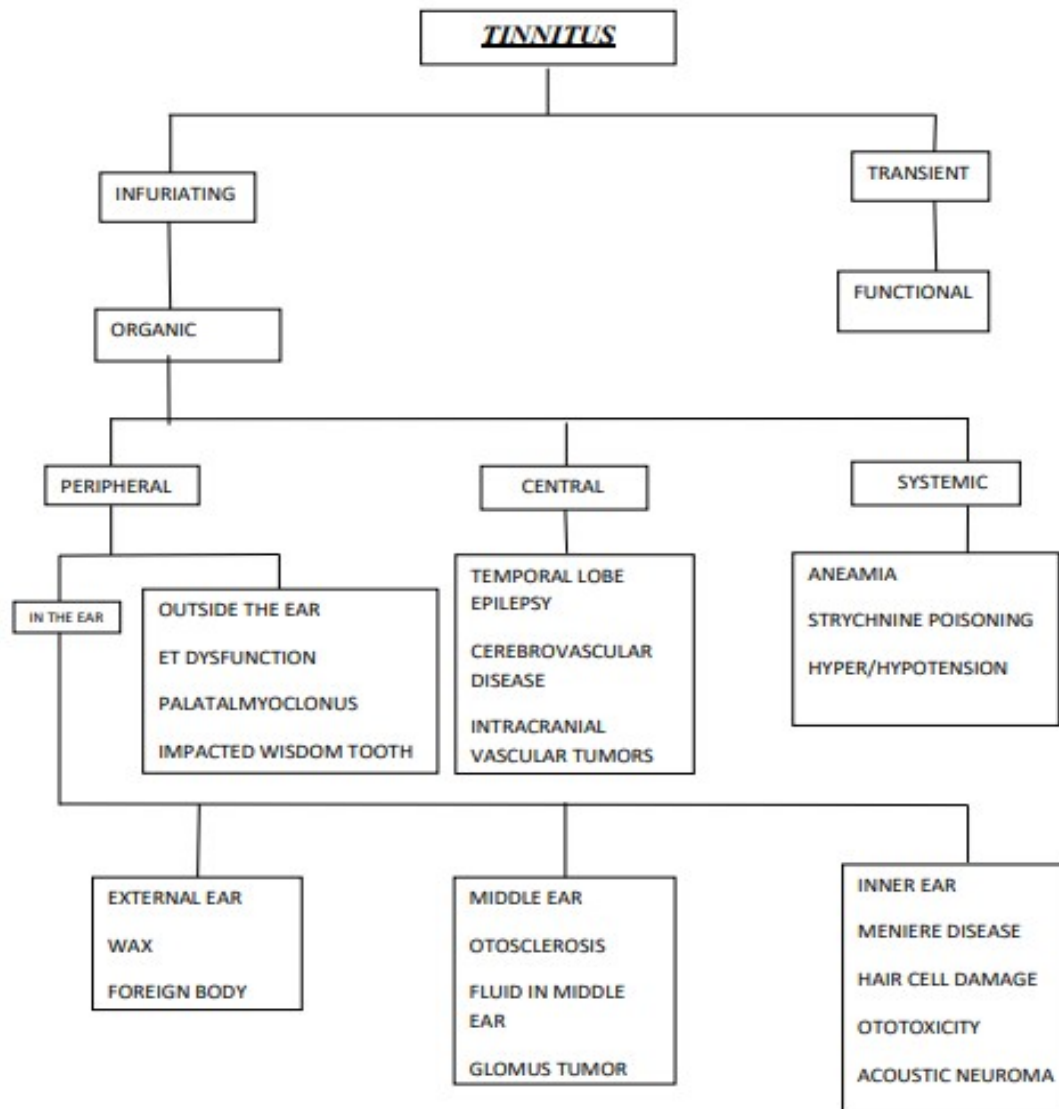


Figure 1: Tree Diagram Explaining Causes of Tinnitus

VIII. ASSESSMENT

Tinnitus assessment protocol.(Goldstein & Shulman 1991, & Hall et al. 2001).

- Pitch matching
- Loudness matching
- Masking

Pitch Matching and Loudness Matching:

Pitch Matching Protocols: Several protocols are available to estimate tinnitus pitch.

- 1. Method & Limits: (Small, 1973):** Patients could be inquired about whether their tinnitus sounds higher or lower in pitch compared to a pure tone. The pitch match frequency is determined by calculating the average of several sets of trials where tones are adjusted in ascending and descending pairs. For instance, if two tones, f_1 and f_2 , are presented and the patient perceives f_1 as lower in pitch, subsequent tones like $f_2 + \text{higher}$ and $f_3 -$ can be utilized, which is feasible with standard clinical audiometers. This procedure aids in establishing the patient's pitch perception of their tinnitus.
- 2. Adjustment Method:** Method of adjustment involves the patient adjusting the frequency of a tone until its pitch matches closely with the primary pitch of their tinnitus.
- 3. Adaptive Methods:** Adaptive methods involve computer-controlled procedures where the patient determines if a tone's pitch is higher or lower than their tinnitus. Penner&Bilger (1992) discovered that using a 'double staircase' adaptive approach yielded less variability compared to the method of adjustment.

In all pitch matching techniques, ensuring that the loudness of the pure tone closely resembles the tinnitus loudness across various frequencies is crucial. Many patients can accurately select the loudness and pitch of a pure tone that closely mirrors their tinnitus. However, when repeated pitch matching occurs, disparities of over an octave can frequently arise between the matches, as observed by Henry et al. in 2004.

- 4. Procedure:** In the pitch and loudness matching process outlined by A. Henry & Zaugg (2005), the "Tinnitus ear" and "Stimulus ear" are identified, along with determining the ear with the most pronounced tinnitus. The stimulus is then presented to the opposite ear. If thresholds are imbalanced and there's reported distortion, it could indicate binaural deplacuis, requiring careful consideration.

Ensure patient comprehension of "loudness" and pitch. Patients often confuse these concepts during tinnitus tone matching (Vernon & Fenwick, 1984). Clarify using relatable analogies: equate pitch to piano keys, differentiate male and female voices for pitch, liken loudness to radio volume settings.

For tinnitus matching using an audiometer, start with the objective of identifying the frequency of a pure tone closest to the tinnitus pitch. Initiate below the perceived tinnitus pitch for clear differentiation. Roughly 90% of patients choose 2 kHz or higher as pitch (Meikle et al. 2004), making 1 kHz a suitable start, termed the "mid-pitched tone."

Tones in octave steps are presented to approximate the tinnitus octave frequency. Verify the pitch-matched tone with tones an octave higher and lower to avoid octave confusion errors (Evered&Lawrenson, 1981; Graham & Newby, 1962; Vernon & Meikle, 1988).

The second objective determines the loudness level of the pitch-matched tone resembling tinnitus loudness. After pitch matching, establish the threshold of the matched tone, then increment in 1 dB steps to determine loudness match at pitch frequency, presented close to tinnitus loudness.

Starting with 1 kHz at 10-20 dB SL, adjust levels accordingly. Proceed to adjacent octave frequencies with approximate tinnitus loudness. Confirm pitch match using octave-confusion testing, presenting the matched tone and tones one octave above and below.

Determine whether tinnitus resembles a tone or noise:

- Compare the matched tone and noise at same frequency and loudness.
- If tone selected, testing stops.
- If noise selected, distinguish between narrowband noise (NBN) and broadband noise (BBN).
- After test match selection, obtain hearing threshold and tinnitus loudness.

Plot the tinnitus match on an audiogram:

- Typically plotted for counseling.
- If the match is a tone, mark a point at frequency and dB HL.
- If NBN, draw a short horizontal line at dB.
- If BBN, correspondingly plot a horizontal line.

IX. MANAGEMENT OF TINNITUS

The primary objective is to enhance habituation to tinnitus rather than completely "curing" it. Many individuals do not actively pursue treatment for tinnitus. There exists a wide range of potential treatment options, although issues with scientific evidence complicate the landscape.

Fundamental advice provided to patients includes:

- Offering reassurance
- Steering clear of exacerbating factors like noise and NSAIDs
- Reducing consumption of stimulants such as caffeine and nicotine
- Practicing relaxation techniques
- Avoiding situations of silence
- Incorporating white noise, for instance, detuned radio, as a strategy.

- 1. Hearing Assistive Aid:** Numerous techniques for managing tinnitus advocate utilizing sound as a therapeutic tool. Hearing aids have been employed for both masking and habituation-based tinnitus therapies, such as tinnitus retraining therapy. The use of sound therapy via hearing aids can alleviate tinnitus through various mechanisms. Amplified sounds can heighten neuronal activity, diminishing the contrast between tinnitus and background neural processes. Adjusting the amplification of speech and ambient sounds to a comfortable level may minimize the audibility and awareness of tinnitus. This interference with the central processing of tinnitus results in reduced attention directed towards it. A substantial number of hearing professionals (88%) view hearing aids as their primary approach to tinnitus treatment, while a significantly smaller portion of patients (24%) consider hearing aids as a self-selected option.

- 2. Cochlear Implant:** Patient having severe or profound hearing loss with tinnitus can go for cochlear implant. Recent research has explored the use of cochlear implant-induced electrical stimulation to suppress tinnitus. After cochlear implant surgery, certain individuals report either complete or partial alleviation of symptoms, even in the opposite ear. The mechanisms behind this suppression remain unclear (Yonehara et al, 2006). If a cochlear implant proves successful in enabling the perception of external sounds, it often leads to reduced tinnitus perception, particularly on the side where the implant is placed.

However, it's important to note that cochlear implants cannot be considered a dedicated tinnitus treatment. These implants are pursued when individuals with hearing loss gain no benefit from hearing aids, but they are costly, particularly in countries like India where a significant portion of the population lives below the poverty line. Moreover, cochlear implants primarily benefit those with hearing loss, leaving only a fraction of the population experiencing tinnitus covered by this approach.

- 3. Tinnitus Masker:** The utilization of externally generated sounds to alleviate tinnitus severity provides relief for certain individuals. Tinnitus maskers generate bands of noise, ideally with adjustable frequency emphasis, empowering users to select the most suitable noise band to attain optimal coverage or masking of their tinnitus, utilizing the lowest achievable sound level. The objective of masking is not to conceal or "mask" the tinnitus but to employ sound as a means to alleviate the stress or tension induced by tinnitus (Hobson, Chisholm, El Refaie, 2010).

Environmental sound generators, resembling radios, produce gentle, calming sounds commonly heard in nature, such as flowing water, rustling leaves, or ocean waves. Particularly beneficial when placed by the bedside, these generators can divert attention from tinnitus as one falls asleep. Many models include timers to automatically turn off after sleep onset. Ear-level sound generators, resembling hearing aids, are recommended for those with normal or mild hearing loss. For individuals with more substantial hearing loss, certain hearing aids feature integrated sound generators, termed combination instruments. Effectiveness of this treatment relies on the device being active, although some devices yield residual inhibition, causing the tinnitus to remain imperceptible even after the sound generator is deactivated.

- 4. TRT:** Tinnitus Retraining Therapy (TRT) is grounded in the neurophysiological model of tinnitus, developed in the late 1980s by Pawel Jastreboff and Jonathan Hazell. This model proposes that the limbic system, responsible for emotions, confers significance and interpretation to tinnitus sounds. According to this perspective, tinnitus sounds are perceived as threatening or perilous, eliciting an emotional reaction. Consequently, our perception of tinnitus intensifies, making it seem louder or more constant. TRT integrates counseling and low-level sound therapy, with its focus not directly on altering tinnitus but on reshaping awareness and comprehension of it. Over time, reduced sensitivity to these sounds emerges, causing tinnitus to be noticeable only when deliberately concentrated upon. This phenomenon is termed 'habituation,' embodying TRT's ultimate objective.
- 5. Nocturnal Sound Therapy:** Nocturnal sound therapy represents an innovative approach to addressing subjective tinnitus by providing treatment during sleep without disrupting the patient's daytime engagements (Pedemonte et al., 2010). The approach involves delivering a sound stimulus adjusted to match the intensity of the patient's tinnitus,

administered via devices like iPods or compatible alternatives. The concept behind this therapy is that sound stimulation mirroring the frequency and intensity of the tinnitus could help restore equilibrium to the central processing of information. This approach acknowledges the continuous operation of the auditory system even during sleep, where it processes incoming auditory input.

- 6. Neuromonics Tinnitus Treatment:** Originating in Australia, this treatment comprehensively addresses the auditory, psychological, and neurological components of tinnitus disruption. It involves delivering a modified acoustic signal, adapting the music digitally by compressing lower frequencies and expanding higher frequencies while retaining its artistic quality. The soothing music aligns with a resting heart rate. Tailored for each ear based on hearing levels across the range of 250 Hz to 12,500 Hz, this customization accommodates hearing disparities and ensures robust neural stimulation from the music (Meltzer, 2007).

Known as Neuromonics Tinnitus Treatment, it combines acoustic stimulation with structured counseling and support provided by clinicians specializing in tinnitus rehabilitation (Davis et al., 2008). While following a procedure similar to TRT, Neuromonics treatment takes a more methodical approach that factors in hearing differences between the two ears. This approach holds promise for enhanced improvement in individuals experiencing tinnitus.

- 7. Ultrasonic Vibration Therapy:** Ultraquiet is an advanced technique involving high-frequency bone conduction therapy with the intention of diminishing the long-term severity of tinnitus. This therapy administers amplitude-modulated musical tones within the 10-20 kHz range. It is founded on the notion that employing high-frequency masking could offer substantial relief for individuals grappling with severe and troublesome tinnitus (Goldstein et al, 2005). The approach of high-frequency stimulation endeavors to halt and potentially reverse the process of cortical reprogramming, potentially restoring a more typical frequency map.
- 8. Drug Therapy:** Antidepressants can play a significant role in addressing tinnitus linked with major depression or depressive symptoms, particularly in severe or prolonged cases. Certain tricyclic medications with sedative properties have demonstrated effectiveness in managing insomnia. Medications binding to GABA receptors, such as benzodiazepines, show promise for tinnitus treatment. Clinical research on prostaglandins and vasodilators has yielded varying outcomes (Swain and Dubey, 2022).
- 9. Cognitive Therapy / Cognitive Behavioral Therapy / CBT:** Cognitive behavioral therapy (CBT) employs strategies like cognitive restructuring and relaxation to reshape how patients perceive and react to tinnitus. CBT aims to alleviate negative associations, minimize stress and annoyance related to tinnitus, and shift attention away from the tinnitus sound. It proves effective for individuals with tinnitus who experience emotional and psychological distress, as sleep problems and even suicidal thoughts can be reported. Tinnitus sufferers might encounter attention issues and anxiety, with those most distressed potentially having psychological susceptibility (Langguthet, 2011).

Cognitive behavioral therapy, such as restructuring thought patterns and habituating reactions to tinnitus, can significantly enhance quality of life and the ability to

cope with chronic tinnitus (Martinez-Devesa et al, 2010). Hesseret. al. (2011) conducted a review of studies assessing the effectiveness of cognitive-behavioral therapy for tinnitus distress, concluding that these studies strongly support its use.

While CBT alone cannot reduce tinnitus loudness, it complements other techniques like sound therapies, addressing disturbances caused by tinnitus in personal and social aspects of life.

- 10. Physiological Feedback Therapy:** The intent of biofeedback techniques is to instruct patients in managing or adapting to the perceived ringing and the subsequent distress associated with tinnitus. Given that tinnitus is a source of stress, which in turn can exacerbate tinnitus, biofeedback focuses on relaxation to control stress by altering physiological responses. By utilizing electrodes attached to the skin, data on pulse, skin temperature, and muscle tension is conveyed to a computer, which then presents the information on a monitor. Through this feedback, patients learn to modify these processes and mitigate the body's stress response by changing their thoughts and emotions. Listening to the audio signal is believed to reduce the perceived ringing and muscle tension.
- 11. Stress Reduction Therapy:** These methods are used to shift the patient's focus away from the sound, contributing to psychological enhancement of their symptoms (Ireland, Wilson, Tonkin, et al., 1985). This approach improves the patient's overall quality of life. However, relaxation therapy is most effective when used in conjunction with techniques aimed at reducing tinnitus severity. These combined techniques not only alleviate tinnitus but also mitigate its associated effects such as stress, insomnia, and psychological disturbances stemming from tinnitus.
- 12. Neuro-Feedback Therapy:** Neurofeedback, a computer-based learning approach, empowers individuals to consciously modify their brain activity. Those suffering from chronic tinnitus exhibit distinct brain activity patterns compared to those with normal hearing (Weisz et al., 2005). Abnormal oscillatory brain activity is common among tinnitus patients, and this irregularity can be addressed through neurofeedback techniques, particularly by enhancing tau activity (8-12 Hz) and adjusting Alpha and Delta frequencies (Crocetti et al., 2011). Notably, altering cortical networks via neurofeedback therapy has been reported as beneficial in reducing tinnitus loudness and distress (Schlee et al., 2008).
- 13. Virtual Reality Exposure Therapy:** It engages with the sub-cortical integration mechanisms, enabling patients to voluntarily control or "master" their tinnitus within a three-dimensional (3D) virtual environment involving both visual and auditory aspects (Londero et al., 2010). The technique is built upon a combination of visual virtual reality and precise auditory spatial representation, enhanced through two interacting components. This approach involves creating an auditory avatar, essentially the patient's tinnitus sound, and incorporating it into an interactive auditory-visual virtual setting. Patient navigation and manipulation influence the spatialized audio components.

Londero et al. (2010) proposed that immersive virtual reality could contribute to tinnitus treatment by fostering plasticity through active manipulation of a 3D auditory element coupled with a visual representation. The repeated sessions of these virtual

reality immersions are believed to encourage cerebral plasticity (Pandey, 2011) and potentially offer tinnitus relief. Nonetheless, thorough clinical research is essential to establish the practical effectiveness of this approach in tinnitus alleviation.

- 14. Acupuncture:** Acupuncture is integral part of traditional Chinese medicine that is used extensively around the world. A number of studies show varying degrees of success and failure in treating tinnitus (Andersson&Lyttkens, 1996)
- 15. Transcutaneous “black boxes”:** The Therapak, a small black box with flashing lights, has been promoted for the treatment of musculoskeletal aches and pains and suggested in the treatment of tinnitus in the UK. *have suggested that this device did give significant help in 45% of patients treated.* Benefits are not good as examination of the inside of the box by an electronics engineer suggested that there were no components capable of producing any type of electromagnetic radiation able to penetrate the body.
- 16. Laser Therapy:** Numerous investigations involving both patient trials and studies on temporal bones have consistently yielded unfavorable outcomes for laser treatment (Partheniadis-Stumpf et al., 1993; Shiomi et al., 1997; von Wedel et al., 1995). In a controlled human study, tinnitus improvement was not observed, and assessments from the temporal bone study revealed that the laser light failed to penetrate in the undamaged ear (Mirz et al., 1999)
- 17. Hyperbaric Oxygen Therapeutic Application:** Hyperbaric oxygen therapy has historically been employed as an experimental approach for sudden sensorineural deafness. This is based on the idea that elevating cochlear blood flow and perilymph oxygen levels could encourage the healing of impaired hair cells (Fattori et al., 1996; Vavrina& Muller, 1995). However, efforts to assess its efficacy in Ménière's syndrome treatment found no notable distinction between patients receiving hyperbaric oxygen and a control group (Fattori et al., 1996).
- 18. Various Herbal Therapeutic Interventions:** Over time, numerous herbal blends with appealing names, suggesting their efficacy for tinnitus, have emerged in the market. Despite lacking substantial evidence of their pronounced effectiveness, people continue to purchase these products. The predicament lies in the fact that such products can exacerbate tinnitus. This is because, once the transient placebo effect fades, patients are further convinced that "nothing works for tinnitus."
- 19. Method of Reflexology, Hypnosis, Aromatherapy, Craniosacral Therapy:** Methods like reflexology, hypnosis, aromatherapy, and craniosacral therapy fall under non-specific treatments often employed to alleviate stress and stress-related ailments such as headaches, anxiety, and digestive issues. These therapies involve actions like massaging the scalp muscles or the soles of the feet and applying pleasant-smelling oils to induce relaxation and a sense of well-being. While these treatments may yield relaxation and improved well-being, they are typically administered by practitioners without specialized knowledge of audiology or tinnitus neurophysiology, making their application to these conditions somewhat random. Tinnitus patients occasionally report some relief, particularly in anxiety reduction, following these therapies.

20. Music Therapy: Drawing from a well-established background in psychology and medicine (Cabrera & Lee, 2000; Lipe, 2002) music-based therapies have been suggested for tinnitus treatment. While these therapies could offer relaxation and stress reduction benefits, similar to other treatments, they might work best in conjunction with TRT (Tinnitus Retraining Therapy) and are anticipated to provide temporary relief by modifying autonomic activity.

21. Pharmacological Therapy

- Medications → Vasodilators: Enhance cochlear blood flow but no useful effect.
- Local anesthetics → Reliably attenuate tinnitus for a short time. Intravenous hydrazine attenuates tinnitus for a short time (Duckert and Res, 1983)
- Sedatives and Tranquilizers
 - Can reduce the severe anxiety and panic that often accompany tinnitus.
 - they can relax muscle and decrease anxiety.
 - Benzodiazepines create a physiological dependence
- Antidepressants → Short to medium term antidepressant therapy may be valuable.
- Anti allergic → Treatment with aspirin suppresses somatosounds resulting from SOAE in cochlea (Penner and Coles 1992).

22. Transcutaneous Vagus Nerve Stimulation: Transcutaneous Vagus Nerve Stimulation (tVNS) is a non-invasive method of stimulating the vagus nerve through the skin. This technique has been explored as a possible remedy for tinnitus. tVNS has the potential to mitigate tinnitus symptoms by regulating neural activity and impacting the brain's interpretation of the condition. This stimulation primarily focuses on the auricular branch of the vagus nerve.

23. Massage with Guasha: While it has been traditionally used in Chinese medicine for promoting blood circulation and relieving muscle tension, its effectiveness in treating tinnitus is mainly anecdotal. No published clinical trials or peer-reviewed studies were found, indicating a lack of robust evidence for Guasha's role in tinnitus management. It will target the cervical branch of vagus nerve.

REFERENCES

- [1] Andersson, G., & Lyttkens, L. (1996). Acupuncture for tinnitus: Time to stop?. *Scandinavian Audiology, 25(4), 273-275.
- [2] Cabrera, I. N., & Lee, M. H. M. (2000). Reducing noise pollution in the hospital setting by establishing a department of sound: A survey of recent research on the effects of noise and music in health care. Preventive Medicine, 30(4), 339-345.
- [3] Crocetti, E., Fermani, A., Pojaghi, B., & Meeus, W. (2011). Identity formation in adolescents from Italian, mixed, and migrant families. Child & Youth Care Forum, 40, 7-23.
- [4] Davis, A., & El Rifaie, A. R. S. (2000). Tyler. Epidemiology of tinnitus. Tinnitus Handbook, 1-25.
- [5] Davis, P. B., Wilde, R. A., Steed, L. G., & Hanley, P. J. (2008). Treatment of tinnitus with a customized, dynamic acoustic neural stimulus: A controlled clinical study. Ear and Hearing, 29(3), 365-375.
- [6] Drexler, D., López-Paullier, M., Rodio, S., González, M., Geisinger, D., & Pedemonte, M. (2016). Impact of reduction of tinnitus intensity on patients' quality of life. International Journal of Audiology, 55(1), 11-19.
- [7] Duckert, L. G., & Rees, T. S. (1983). Treatment of tinnitus with intravenous lidocaine: A double-blind randomized trial. Otolaryngology-Head and Neck Surgery, 91(5), 550-555.

- [8] Evered, D., &Lawrenson, G. (1981). Confusions and illusions in pitch perception. *The Journal of the Acoustical Society of America*, 70(2), 393-401.
- [9] Fattori, B., Nacci, A., Ursino, F., Sellari-Franceschini, S., Berrettini, S., &Guerrini, M. (1996). Evaluation of a potential new treatment for Ménière's disease. *Otology &Neurotology*, 17(3), 529-534.
- [10] Goldstein, B., Lenhardt, M. L., & Shulman, A. (2005). The response of tinnitus to high-frequency vibration therapy. *Ear and Hearing*, 26(1), 1-11.
- [11] Henry, J. A., &Zaugg, T. L. (2005). An introduction to the Tinnitus Functional Index (TFI). *Journal of the American Academy of Audiology*, 16(6), 378-379.
- [12] Henry, J. A., Flick, C. L., Gilbert, A., Ellingson, R. M., &Fausti, S. A. (2004). Comparison of manual and computer-automated procedures for tinnitus pitch-matching. *Journal of Rehabilitation Research & Development*, 41(2).
- [13] Hesser, H., Weise, C., Westin, V. Z., &Andersson, G. (2011). A systematic review and meta-analysis of randomized controlled trials of cognitive-behavioraltherapy for tinnitus distress. *Clinical Psychology Review*, 31(4), 545-553.
- [14] Hobson, J., Chisholm, E., & El Refaie, A. (2010). Sound therapy (masking) in the management of tinnitus in adults. *Cochrane Database Systematic Review*.
- [15] Ireland, C. E., Wilson, P. H., Tonkin, J. P., & Platt-Hepworth, S. (1985). An evaluation of relaxation training in the treatment of tinnitus. *Behaviour Research and Therapy*, 23(4), 423-430.
- [16] Jastreboff, P. J., &Jastreboff, M. M. (2003). Tinnitus retraining therapy for patients with tinnitus and decreased sound tolerance. *Otolaryngologic Clinics of North America*, 36(2), 321-336.
- [17] Jastreboff, P. J. (1995). Tinnitus as a phantom perception: Theories and clinical implications. In: Vernon J, Moller AR, eds. *Mechanisms of Tinnitus*. Boston: Allyn& Bacon, 73-94.
- [18] Langguth, B., Kleinjung, T., &Landgrebe, M. (2011). Severe tinnitus and depressive symptoms: A complex interaction. *Otolaryngology - Head and Neck Surgery*, 145(4), 519-522.
- [19] Londero, A., Viaud-Delmon, I., Baskind, A., Delerue, O., Bertet, S., Bonfils, P., &Warusfel, O. (2010). Auditory and visual 3D virtual reality therapy for chronic subjective tinnitus: Theoretical framework. *Virtual Reality*, 14, 143-151.
- [20] Martinez-Devesa, P., Perera, R., Theodoulou, M., & Waddell, A. (2010). Cognitive behavioural therapy for tinnitus. *Cochrane Database of Systematic Reviews*, (9), CD005233.
- [21] Meikle, M. B., Stewart, B. J., Griest, S. E., Martin, W. H., & Henry, J. A. (2004). Tinnitus outcomes assessment. *Trends in Amplification*, 8(3), 63-83.
- [22] Meltzer, J. I. L. L. (2007). *Neuromonics Tinnitus Treatment. Tinnitus Today*.
- [23] Mirz, F., Pedersen, C. B., Ishizu, K., Johannsen, P., Ovesen, T., Stødkilde-Jørgensen, H., &Gjedde, A. (1999). Positron emission tomography of cortical centers of tinnitus. *Hearing Research*, 134(1-2), 133-144.
- [24] Nondahl, D. M., Cruickshanks, K. J., Wiley, T. L., Klein, R., Klein, B. E., & Tweed, T. S. (2002). Prevalence and 5-year incidence of tinnitus among older adults: The epidemiology of hearing loss study. *Journal of the American Academy of Audiology*, 13(6), 323-331.
- [25] Pandey, V. K. (2011). Role of virtual reality in tinnitus therapy. *American Journal of Otolaryngology*, 32(5), 358-362.
- [26] Partheniadis, G. T., Maurer, J., & Mann, W. (1993). Laser therapy in acute tinnitus. *Lasers in Surgery and Medicine*, 13(1),72-79.