

# Tinnitus Retraining Therapy

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According to the Jastreboff's neurophysiological model of tinnitus, if negative associations are attached to the tinnitus signal, tinnitus is perceived to be a threat or a danger and it activates the autonomic nervous and limbic systems. Consequently patient's awareness of tinnitus is heightened and so patient perceives it to be louder and more persistent. Jastreboff and Hazell started tinnitus retraining therapy (TRT) based on the neurophysiological model of tinnitus. The purpose of TRT is blocking tinnitus from activating the sympathetic nervous and limbic systems (habituation of reaction) and from reaching the cerebral cortex (habituation of perception). TRT is composed of two components directive counseling that tries to reclassify tinnitus into the meaningless stimuli and sound therapy that decreases the relative strength of the tinnitus signal. Physicians try to put patient's tinnitus into the territory of meaningless stimuli through retraining the brain (habituation of reaction). Because the brain habituates all unimportant stimuli, if habituation of reaction is fully achieved, habituation of perception will follow automatically. In most clinical results, clinical success rates of TRT approach or exceed 80% improvement. Early improvement can be achieved during the first few months, followed by additional progressive improvement. It should be recommended that the patient continue treatment at least 18 months.

**Key Words:** Tinnitus Retraining Therapy; Tinnitus; Sound Therapy

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## INTRODUCTION

Before the Jastreboff's neurophysiological model of tinnitus was published [1], many treatment methods for tinnitus tried to remove or, at least decrease the tinnitus signal. But, all treatments failed to eliminate tinnitus at its source. Although a definite cure for tinnitus does not exist until now, various management strategies have been developed to improve symptoms and relieve distress. One of the most widely used treatment modalities for tinnitus is Tinnitus retraining therapy (TRT). TRT is rigidly based on the neurophysiological model of tinnitus [2,3].

## NEUROPHYSIOLOGIC MODEL OF TINNITUS

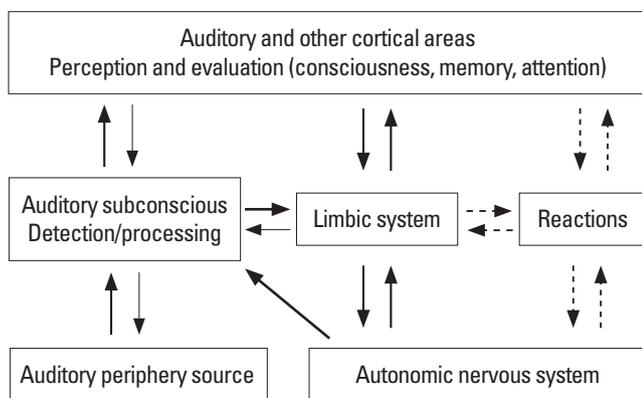
The Jastreboff's neurophysiological model of tinnitus was postulated from these observations. Most people having tinnitus are just hearing tinnitus with a sound, without any bothersome reactions to it. Only about 20% of people with tinnitus (clinically sig-

nificant tinnitus) have bothersome reactions induced by tinnitus such as panic attacks, anxiety, and problems with concentration [4]. And psychoacoustic characteristics of tinnitus (pitch, loudness, and maskability) have no correlation with the severity of tinnitus [5]. So, the severity of tinnitus can differ dramatically from person to person even if two people have identical psychoacoustical characteristics of tinnitus. It means the auditory system does not play a primary role in tinnitus that cause suffering but that non-auditory systems in the brain have a dominating role in creation of clinically significant tinnitus. Jastreboff postulated that negative, bothersome reactions to tinnitus resulted from inappropriate activation of the sympathetic nervous and limbic systems by the tinnitus signal [1,6].

According to the Jastreboff's model, initially, the tinnitus related neuronal activity is generated at the peripheral auditory system. The subconscious level of the brain may then detect this signal. After then, the auditory cortical areas perceive and evaluate this signal. Tinnitus is evaluated and compared with information

stored in memory. If the person's tinnitus does not have negative associations, the tinnitus signal is subsequently interrupted from contacting conscious perception. But, if tinnitus gets some negative associations, it is classified in the category of unpleasant or dangerous stimuli and consequently activates the autonomic nervous and limbic systems, so it results in anxiety, stress, panic attacks, and loss of wellbeing. This in turn enhances detection of tinnitus, and further enhances the activation of autonomic nervous and limbic systems. Jastreboff showed this vicious cycle with Fig. 1. Neuro-imaging studies have provided scientific evidence for the neurophysiological model of tinnitus. High activation of the limbic structures and non-auditory cortical areas has been founded by these studies [7-10].

Principles of conditioned reflexes control connections between tinnitus and the autonomic nervous and limbic systems. In the Jastreboff's model, a conditioning stimulus is tinnitus, which activates the autonomic nervous and limbic systems and in consequence of this activation, patients with clinically significant tinnitus feel anxiety, stress, panic attacks, and loss of wellbeing. And these responses act as negative reactions. Severe stress and negative counseling can act as reinforcements. Severe stress can occur from health problems that are irrelevant to their tinnitus, divorce,



**Fig. 1.** The Jastreboff's neurophysiological model of tinnitus. Initially, the tinnitus related neuronal activity is generated at the peripheral auditory system. The subconscious level of the brain may detect this signal. After then, the auditory cortical levels perceive and evaluate this signal. Tinnitus is evaluated and compared with information stored in memory. If the person's tinnitus does not have negative associations, tinnitus signal is subsequently interrupted from contacting conscious perception. But, if tinnitus gets some negative associations, it is classified in the category of unpleasant or dangerous stimuli and consequently activates the autonomic nervous and limbic systems, so results in anxiety, stress, panic attacks and loss of wellbeing. This in turn enhances detection of tinnitus, and further enhances the activation of autonomic nervous and limbic systems.

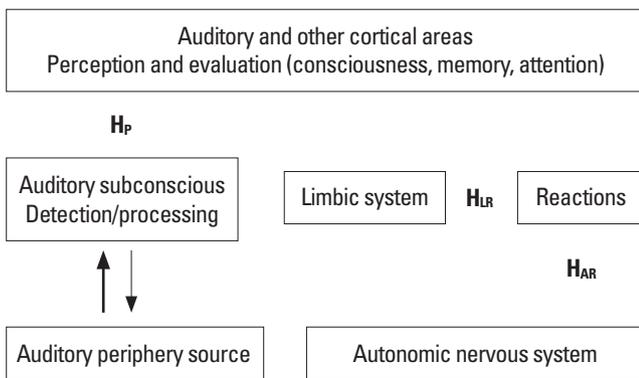
retirement, and so on. Examples of such negative counseling are "You will hear tinnitus for life", "We do not have anything can be done for your tinnitus", "You should just learn to live with tinnitus", "We need to take a brain MRI because you may have a brain tumor". As a result of negative counseling, patients think tinnitus as a sign that their hearing will be worse or there is something wrong with their brain. Therefore, they begin to pay their attention to tinnitus. Unfortunately, negative counseling is very common.

Once the reflex is established, a tinnitus-evoked negative reaction in itself acts as the reinforcement. For this reason, even after the resolution of severe stress, patients still show negative reactions to their tinnitus.

## TINNITUS RETRAINING THERAPY

TRT is a clinical implementation of the neurophysiological model of tinnitus. Retraining the brain to be habituated to tinnitus is the final goal of TRT. The concept of habituation has been used in conditioning and learning in the literature for a long time. It means a reduced responsiveness to repeated stimulation with neutral stimuli. The brain has a high level of plasticity. The nervous systems are constantly revised, resulting in the increased neural response to significant signals, and the diminished neuronal response to neutral signals. When tinnitus related neuronal activities newly occur, or have negative associations, these are treated as important, and evoke an emotional response. This triggers the body to prepare for "fight or flight." But, tinnitus without negative association leads to the extinction of a response to tinnitus. The purpose of TRT is preventing tinnitus from activating the sympathetic nervous and limbic systems (habituation of reaction) and from reaching the cerebral cortex (habituation of perception). Jastreboff represents this idea with a block diagram (Fig. 2).

TRT combines directive counseling and low-level sound therapy. Habituation of reactions is the primary clinical goal of TRT. During directive counseling, physicians educate patients about the auditory system, neurophysiologic model of tinnitus and habituation mechanism. And patients have much inaccurate information about tinnitus. Therefore, providing patients with solid knowledge and answering questions are very important. Enough time should be used to answer the patient's questions and to confirm that the patient understands all educated knowledge. This process is important because a known danger evokes a weaker reaction of the



**Fig. 2.** Ultimate goal of TRT is to retrain the brain to be habituated to tinnitus. Habituation of reaction is preventing tinnitus from activating the sympathetic nervous and limbic systems. If habituation of reaction is fully achieved, patients do not experience negative reactions and habituation of perception will follow automatically, because the brain habituates all unimportant stimuli. If habituation of perception is achieved, tinnitus is blocked before it reaches the consciousness level, and patients do not hear tinnitus.

H<sub>p</sub>, habituation of perception; H<sub>LR</sub>, habituation of limbic reaction; H<sub>AR</sub>, habituation of autonomic reaction.

autonomic system than an unknown danger. According to directive counseling, patients understand that the activation of autonomic nervous and limbic systems is a problem with their bothersome tinnitus, and because the brain has high level of plasticity, habituation of reaction and habituation of perception are possible through retraining the brain. If patients have a good understanding about these concepts, they treat tinnitus as neutral stimuli. Consequently they will gradually habituate their tinnitus.

A lot of patients with bothersome tinnitus are frustrated because they think that physicians do not have any treatment modality that can be done for their tinnitus. As their beliefs change through directive counseling, they feel tinnitus is a much more benign disease. So, they can start habituation. If habituation of reaction is fully achieved, patients do not experience negative reactions and habituation of perception will follow automatically because the brain habituates all unimportant stimuli. If habituation of perception is achieved, tinnitus is blocked before it reaches the consciousness level, and patients do not hear tinnitus.

Sound therapy is applied to most TRT patients. Up to the present, there was no way of decreasing the tinnitus-related neuronal activity directly. But, we can decrease the relative strength of the tinnitus signal, through increasing background neuronal activity which can be done by exposing patients to low-level sounds. According to decreasing of the relative strength of the tinnitus signal, the strength of activation of the autonomic nervous and limbic

systems is reduced. As a result, the negative reinforcement in the conditioned reflex arcs is decreased. Thereby habituation becomes easier. When using a sound generator, tinnitus should never be masked in TRT, because patients cannot be habituated to a sound that they cannot hear.

## OUTLINE OF TRT

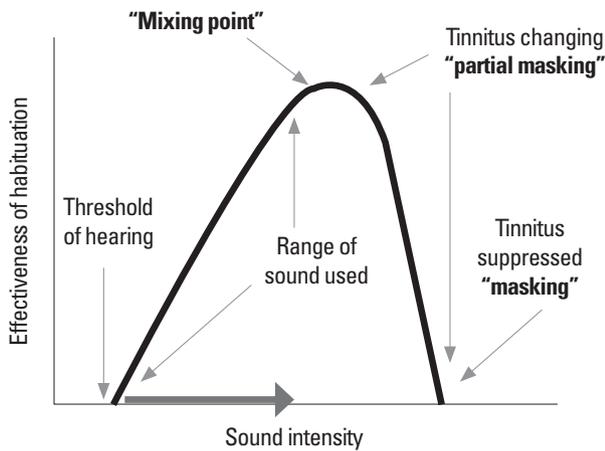
The treatment schedule of TRT is composed of an initial appointment and several follow-up visits. The initial interview consists of (1) physical examination, (2) audiologic evaluation, (3) tinnitus severity evaluation using questionnaires, (4) determining the treatment category, (5) directive counseling, and (6) fitting sound generator or hearing aid. Before beginning directive counseling, physicians should do a full ENT and audiological examination and manage treatable otologic diseases in the usual way.

To evaluate tinnitus severity and to check a change in tinnitus severity, we use questionnaires before, during, and after treatment. The Tinnitus Handicap Inventory (THI) [11,12] and a visual analogue scale (VAS) on loudness, awareness, annoyance and effect on life [13] are usually used. Patients are classified into one of five categories on the basis of the questionnaires and audiological examination results. The severity of tinnitus, the degree of hearing loss and the presence of hyperacusis are used for classification [6]. Patients will receive the slight different type of treatment according to the category where they are placed. Jastreboff summarizes the criteria of the category and the treatment according to the category (Table 1).

During directive counseling, explanation of the audiologic results and proper advice on concerns of patients are very important. Frequent concerns of tinnitus patients include: "Will I have difficulty in hearing?", "I worry about tinnitus becoming severe", "I cannot sleep", "I have problems with concentration", and "Is tinnitus a symptom of brain tumor?" The above concerns are indeed common [14]. Using actual examples of habituations are also useful. 'The sound of raindrops falling on a roof is being noticed when it first starts raining, but going unnoticed and put out of mind after some time'. And 'we are normally not aware of the sound of a refrigerator in their kitchen, and even if we do hear the refrigerator sound, it is not annoying'. Physicians should encourage tinnitus patients to check their negative reaction to their tinnitus, and lessen negative reaction little by little each time. Retraining conditioned reflexes takes a long time.

**Table 1.** Categories of tinnitus and hyperacusis patients

Category	Hyperacusis	Prolonged sound induced exacerbation	Subjective hearing loss	Impact on life	Treatment
0	-	-	-	Low	Counseling only
1	-	-	-	High	Sound generator set at mixing point
2	-	-	Present	High	Hearing aid with stress on enrichment of the auditory background
3	Present	-	Not relevant	High	Sound generators set above threshold of hearing
4	Present	Present	Not relevant	High	Sound generators set at the threshold: very slow increase of sound level



**Fig. 3.** The relationship between sound generator volume and the effectiveness of habituation. When the sound generator is used, we usually adjust sound generator volume close to the mixing point, in category 1 patients. Mixing point is the volume of sound generator at which the noise just starts to mix with the tinnitus. The effectiveness of habituation increases as volume proceeds to the mixing point. But, after the sound generator volume is louder than mixing point, masking begins and efficacy quickly decreases. Tinnitus should never be masked in TRT, because patients cannot be habituated to tinnitus that they cannot hear.

When we apply sound therapy to the patient, broad band noise is usually used rather than narrow band noise because broad band noise stimulates wide range of auditory neurons and is more easily endurable than narrow band noise. We usually adjust the sound generator volume close to the mixing point, in category 1 patients. Mixing point is the sound generator volume that noise just begins to mix with tinnitus. The effectiveness of sound generator improves as volume proceeds to the mixing point. But, after the sound generator volume is louder than the mixing point, masking begins and effectiveness quickly decreases. Jastreboff shows the relationship between sound generator volume and effectiveness of habituation with Fig. 3. The sound generator should be used as much as possible or more than 8 hours per day.

Because the habituation course is slow and gradual, and tinnitus

severity can fluctuate during TRT, all patients should be encouraged to return for follow-up visit. During the follow up visits, physicians repeat additional counseling, check the progress of habituation and monitor sound therapy compliance. Jastreboff recommends follow-up sessions at monthly intervals for the first three months and then at 6, 12, and 18 months at the clinical center.

### RESULT OF TRT

Because the objective measurement of tinnitus is impossible, therapeutic effect measurement of TRT commonly uses comparison of the initial questionnaire with the follow-up questionnaire and the VAS scale. Jastreboff emphasizes “clinically significant improvement”. The following criteria were used: (1) at least one activity previously prevented/interfered with is no longer affected or all activities show improvement; (such as sleeping, concentration, quiet recreational activities, sport etc.) (2) tinnitus awareness is decreased by at least 20 percent, the impact of tinnitus on life is decreased by at least 20 percent, and tinnitus annoyance is decreased by at least 20 percent. And for the THI, a decrease of 20 points or more in its score has been used to be clinically significant.

According to Jastreboff’s study, the results of 303 consecutive patients who had initial THI score of at least 36 showed that significant improvement was achieved after 1 month of the treatment with THI score decreasing from 65 to 46, followed by further consistent improvement when followed up to 18 months. After 12 months, 82% of patients showed statistically a significant decrease of 20 points from the initial score [15]. And in most clinical results from various centers, about 80% of cases reach significant improvement using TRT [16-19]. Also in their result, early improvement can be achieved during the first few months, followed by additional progressive improvement. It is recommended that treatment lasts at least 18 months to prevent recurrence. Jastreboff

compared TRT result and cognitive behavior therapy (CBT) in his review article. In the CBT group, statistically significant improvement was observed, but it did not show clinically significant improvement. In the TRT group, a high clinical improvement of 30 points of THI was observed and it was statistically significant [15,20].

But, prospective controlled studies about TRT are rare. A Cochrane review about TRT was published in 2010 that included only one report [21]. It was the clinical trial of Henry which showed TRT to be effective, with statistically significant decline of THI and percentage of annoying time. Specifically, over a period of 18 months in the group with severe tinnitus, THI decreased from 72 to 26.4. The percentage of annoying time by tinnitus decreased from 47.3% to 6.3% [22]. But, the Cochrane review noted that while the study suggested TRT had benefit in tinnitus treatment, the study was not good enough to reach solid conclusions. More prospective trials with comparison groups that include no treatment and placebo conditions are required.

## CONCLUSION

The purposes of TRT are habituation of reactions and habituation of perception. If habituation of reaction is achieved, tinnitus is not annoying anymore. So patients can live an everyday ordinary life. As habituation of perception is achieved, tinnitus perception gradually decreases. When implemented properly, TRT is highly effective, with success rates of around 80% and can be used for any type of tinnitus. TRT course is slow and gradual and it takes 18 months. But, after tinnitus habituation is achieved, the effects of TRT are long-lasting and there are no side effects.

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