

The TRT method in practice

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Tinnitus retraining therapy is one approach by which habituation to tinnitus and hyperacusis can be induced. It is logically based on the neurophysiological model described by Jastreboff (1990) [1]. Considering the complexity of tinnitus and hyperacusis, it is logical and straightforward, both in treating the patient, and in teaching the technique to health care professionals.

The key problem with persistent tinnitus and hyperacusis is an aversive conditioned reflex response, similar to that evoked by security issues, or threats to wellbeing. For as long as this response to internal neuronal activity (in tinnitus) or external sounds (in hyperacusis) is established in the subconscious, it continues to evoke unpleasant alteration of limbic and autonomic function, whenever the signal is detected. Habituation to continuous meaningless sounds occurs rapidly, but does not occur where the sound has a negative, invasive, or threatening message. The goal of TRT is to habituate or block completely any reaction of the limbic or autonomic nervous system to tinnitus, or, in hyperacusis, to sound in the environment, which is causing annoyance. The technique requires a specific approach in which tinnitus and hyperacusis is first categorised, and an individual programme of retraining on a one-to-one basis is designed for each patient, dependent on 5 different treatment categories. All treatments involve directive counselling/teaching, training in sound enrichment of the environment and avoidance of silence. Some categories involve the use of instruments (either noise generators or hearing aids), fitted and used in the specific context of the neurophysiological model. The vital component for both professionals and patients is a complete understanding of the model.

TRT assessment and diagnosis

Before beginning TRT a full ENT and audiological assessment will be made using the best practice criteria. Treatable otological conditions will be managed in the usual way, with particular care being taken not to make tinnitus worse. Increasing patients fears about the malignant nature of their tinnitus must be avoided, particularly when it is necessary to exclude an acoustic neuroma, or in performing surgery which often results in a quite predictable temporary increase of tinnitus postoperatively. In this instance problems can be avoided by proper preoperative counselling, with an understanding of the neurophysiological model, which explains why tinnitus is louder when the ear is blocked with dressings/blood clot.

By diagnosis in TRT we mean the division of patients into specific treatment categories, according to their experience of tinnitus and hyperacusis. This greatly increases the chance of successful treatment. Thus category (1) patients have significant tinnitus, (2) significant hearing loss with tin-

nitus, (3) hyperacusis, (4) hyperacusis with prolonged symptom enhancement by environmental sound exposure, and category (0) have minimal symptoms, not requiring prolonged intervention. Each of these categories requires a different approach, and wrong treatment can make patients much worse, particularly in category (4). It is also important to exclude the possibility of Lyme disease in this category. In each case the diagnosis is dependent on the evaluation of the problem, rather than on audiometric data, so a high frequency hearing loss on the pure tone audiogram without significant hearing difficulty would not put the patient into category (2). In categorisation we are looking for the dominant factor.

Forty percent of tinnitus patients have a degree of hyperacusis [2]. The mechanism is very similar to the emergence and persistence of tinnitus, although in hyperacusis the source of the aversive stimulus is in the patient's external environment, rather than being part of the auditory system. Patients with sound sensitivity need to be assessed by the degree of pure hyperacusis (sensitivity to all sounds), and phonophobia (sensitivity and aversion to specific sounds, without any sensitivity to others). In practice hyperacusis and phonophobia co-exist in varying proportions. An understanding of the

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reasons underlying the reason for phonophobia is essential for appropriate directive counselling which is an important part of the treatment.

The purpose of TRT is to induce habituation, first of the reaction (of the limbic and autonomic nervous system) to the tinnitus signal, and subsequently to habituate the perception of tinnitus itself (although this is not the primary goal). A method of measurement of these parameters is needed to assess the strength of the reaction, (annoyance or distress caused by tinnitus) and the extent of perception (awareness of tinnitus). These parameters can be conveniently recorded as the percentage of waking hours when the tinnitus is experienced (percentage awareness) and the percentage of waking hours when the tinnitus is distressing or annoying (percentage annoyance). New patients may require encouragement to differentiate their tinnitus in this way, as severe tinnitus can be 100% annoying and distressing. If preferred, an analogue scoring chart may be used. In addition we note any activities or 'life factors' which are prevented or interfered with by tinnitus, such as sleeping, concentration, quiet recreational activities, sport etc. A simple record is made of the number of activities interfered with. This approach allows the following questions to be answered:

- what is the severity of the problem (percentage distress)?
- has some habituation of reaction already occurred?
- is distress largely absent? (Category (0) patients)
- after treatment, has the patient achieved a successful result?

In calculating success of treatment we use the percentage improvement in awareness and annoyance together with the number of life factors that have been facilitated. Using the '40% rule' (our practice) patients are assessed as being successfully treated, or graduated, if they have a 40% improvement in annoyance and awareness, or a 40% improvement in annoyance or awareness, plus a facilitation of one life factor.

Audiometric evaluation is always required but the emphasis is different than in conventional audiology. Pure tone audiometry at all fixed frequencies is combined with loudness discomfort levels (LDL) at each frequency. This gives a measure of hearing, and an indication of the dynamic range of the ear. LDLs are reduced consistently below 100 dB in patients with hyperacusis. These measurements will aid in the categorisation of patients into category (3) or (4), but will not be sufficient without an appropriate history of sound sensitivity.

It is our practice to obtain further assessment of cochlear function with transient evoked otoacoustic emissions, and distortion products, as well as looking at the fine structure of the audiogram using Békésy audiometry or Audioscan. The rationale for this is the part played by peripheral hearing in certain cases, where tinnitus emerges as a result

of irregularities of cochlear function (the discordant damage hypothesis [1]). This knowledge is important in following the patient's progress, and in using the correct form of directive counselling. Many patients are convinced (and may have been told) that their symptoms are caused by poor Eustachian function, or by other middle ear problems, and they are constantly looking for a simple treatment to get rid of tinnitus. Impedance testing and middle ear reflex measurements shows normal results in over 98% of our tinnitus clinic patients, and will be needed to persuade patients of the correct mechanism, and appropriate treatment by TRT

Teaching – demystification and retraining.

Patients vary in their reaction to tinnitus from mild annoyance, without any particular fears or anxieties, to those who have a classical phobic reaction to it. In many cases the main preoccupation is with the finality, the concept that tinnitus will go on for ever, may get worse, and cannot be effectively treated. These negative mindsets can only be changed by a proper understanding of tinnitus mechanisms; the neurophysiological model. Compliance with a programme that may last 18 months or more will not be achieved unless the patient understands why it is necessary, and also why there is no 'quick fix'. Again the answers that patients need lie in the model. Many patients with mild symptoms are just keen to know what tinnitus is. It is a basic rule of the auditory system, that any new signal must be monitored until it can be identified, and its meaning established. Again TRT is the only treatment that achieves this reliably.

Understanding the auditory system

To understand fully the neurophysiological model, the basics of the auditory system need to be learned. This includes the ear, and transduction process of the cochlea, the concept of tonotopic mapping, and the process of sorting neurally coded frequency information into meaningful patterns before they are perceived in the auditory cortex (Figure 1).

Sub-awareness neuronal networks have several functions:

- pattern recognition;
- memory;
- links with the limbic and autonomic nervous systems.

Appropriate diagrams and the use of simple language, amply illustrated by stories or parables are essential to take patients through this information, regardless of their educational background. For instance the concept of sub-awareness pattern recognition with enhancement or attenuation of signal can be illustrated by the well-known phenomenon of alertness to the sound of first name, as against the habituation to meaningless sounds like the refrigerator, or traffic on a nearby busy road. The develop-

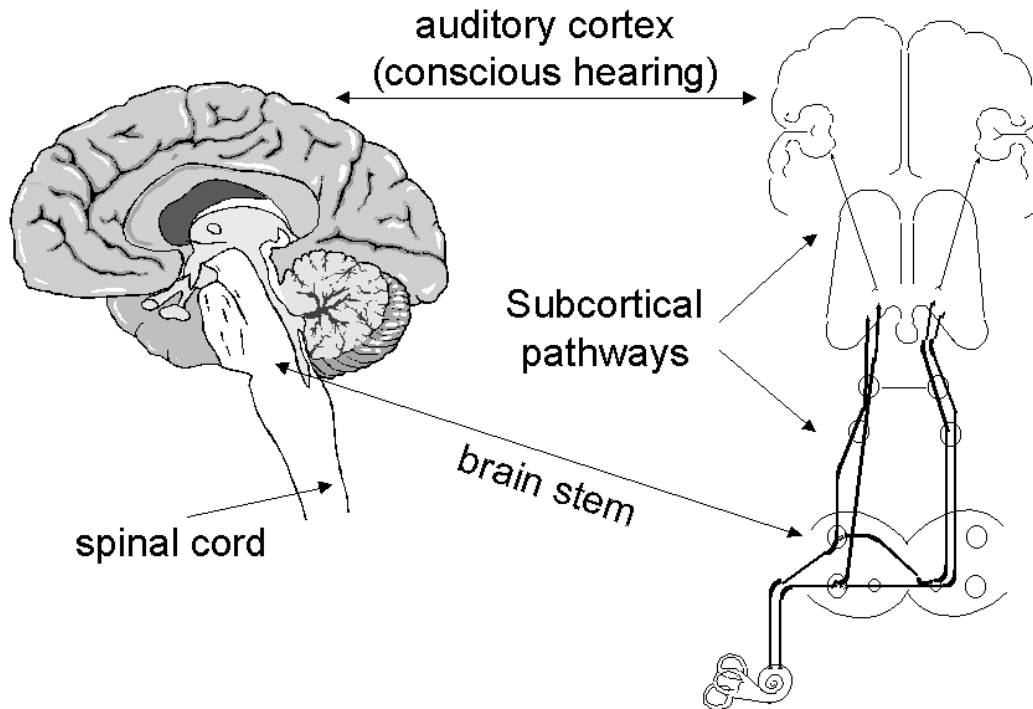


Figure 1 Helping patients understand the importance of auditory perception and sub-awareness processing

ment of these enhancement or suppression effects, take time, and is dependent on a learning process.

Understanding the mechanism of aversive reactions

Pattern recognition plays a vital part in survival and personal security. The reaction to a motor car horn on crossing the road, or a creaking floor-board at night evokes the same limbic and autonomic responses as the sound of a predator to an animal living in the wild. Even a small change in environment, such as elicited by shining a light on an aquatic flat-worm, results in a feeling of annoyance, or

unease, because of a disruption in homeostasis. In each case there is activation of the limbic system to create motivating fear or anger, and autonomic tonal increases to prepare for activity. Once a response has been conditioned it does not habituate, as long as it is concerned with elements of survival (food, procreation or personal security). Identical responses may be generated to harmless elements of our environment because of inappropriate training (e.g. spiders, lifts, aeroplanes and high buildings). Such aversive conditioned responses or reflexes, behave exactly like survival reflexes (Figure 2). They may be generated by any kind of negative reinforcement.

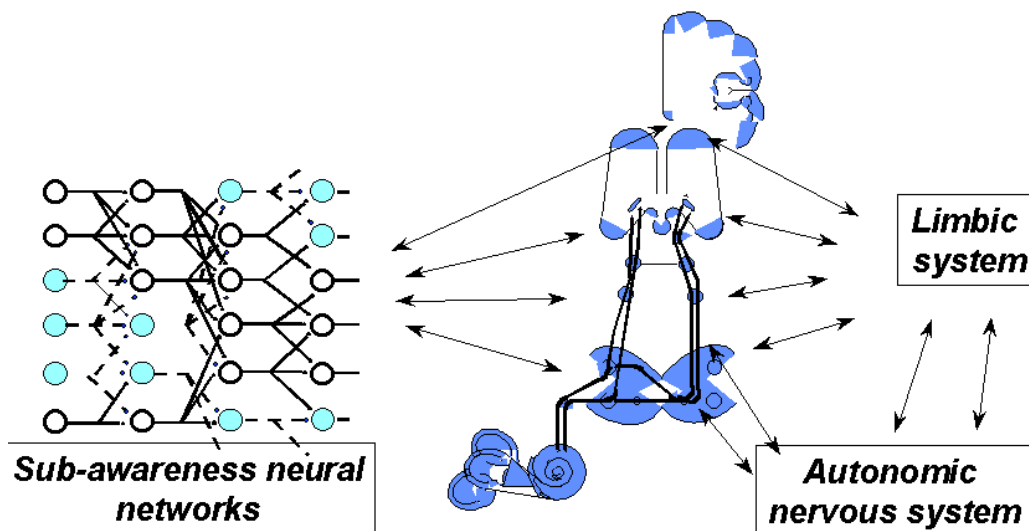


Figure 2 Helping patients understand the relationship of auditory and extra-auditory pathways, and the aversive conditioned reflex

Understanding the Jastreboff neurophysiological model

The various elements relating to tinnitus, its origin, processing of the signal, its first emergence as a perception of sound, and the generation of the aversive conditioned response are explained to the patient using the flow chart (Figure 3).

The principal components involve:

(a) *The source of tinnitus; processing of the signal:*

The source is usually near the periphery of the auditory system, but any neurone in the auditory sub-awareness pathway may contribute to the sounds that are heard. What is perceived at a conscious level is the neural activity present in the highest neurones in this pathway, subsequent to any processing, pattern arranging, enhancement or attenuation that has gone on between ear and brain. In silence, the background activity in the system can be detected easily by almost everyone as shown by Heller and Bergman in 1953 [3]. Where irregularities, even minor ones, of cochlear function exist, these may result in signals which are then imposed on the otherwise random activity of auditory neurones in the absence of sound. The message for the patient being counselled is clear. The source of tinnitus is universal, it is unheard until sub-awareness pattern recognition occurs, and only persists if other criteria are fulfilled.

(b) *Perception and evaluation:* With a knowledge of auditory anatomy and physiology the patient appreciates that sounds are not heard until they reach the auditory cortex. Every new sound has to be evaluated and classified before it may be ignored. The sudden advent of a noise coming from within the head is inherently alarming and understandably leads to a belief that something is wrong. Conventional wisdom about tinnitus is often gained by the patient before its onset, leading to ‘worst fears’

being realised. Subsequently, in a search for help the patient can experience ‘negative counselling’ about the untreatability of tinnitus, its permanence, and the need to ‘put up with it’. Frequently worst fears are not only confirmed, but strongly enhanced. It can be hard work to turn around the thinking of a patient who has received the wrong information from a very eminent colleague. It is worth telling the patient that such information about tinnitus, commonly found in textbooks, is based on a highly skewed population of often phobic tinnitus sufferers, in an era when treatment was largely placebo or ineffective, and before there was accurate idea of tinnitus mechanisms.

(c) *Establishment of the aversive conditioned response:* Once the patient understands the significance of negative evaluation of tinnitus, it can be simply shown by the diagram, that this will inevitably create an aversive response involving an enhancement of limbic and autonomic function. If the evaluation is strongly negative, and fears exist about threatening negative pathology, such as brain tumours or madness, then a strong phobic or aversive reaction can result. On the other hand, only slight, occasional annoyance may result from the loss of homeostasis, or tinnitus being seen as a minor territorial intrusion. Whatever the strength of the reaction, the neurophysiological model applies in every case.

(d) *Vicious circles generated in the conscious and unconscious pathways:* Once an aversive response has been conditioned, several criteria apply:

- The response is ‘set’ in the subconscious, and cannot be ‘turned off’ at will;
- The response will be triggered whenever the signal can be detected;
- The connections are bi-directional and therefore the limbic/autonomic reaction from

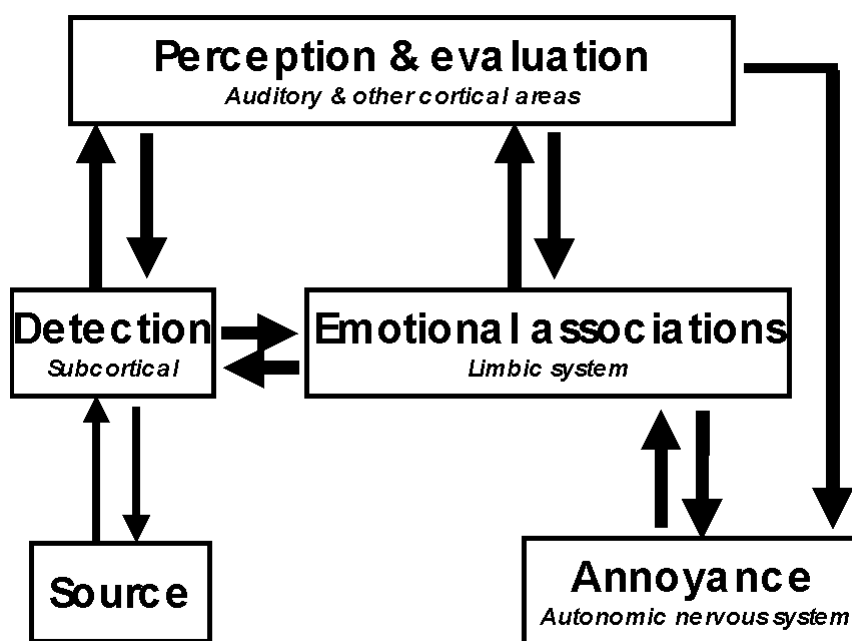


Figure 3 The Jastreboff neurophysiological model

sub-cortical detection of tinnitus enhances the response which in turn enhances detection, and so on, independent of conscious thought;

- Enhanced detection leads to greater perception, and another vicious circle, strengthening the reaction still further. This is the mechanism by which tinnitus perception and reaction can increase without any change in the peripheral auditory system.

(e) *Understanding the difference between emergence and persistence:* It is very difficult for those who have had tinnitus triggered by a strong experience, such as a loud noise, not to feel that the situation is irreversible. It is important to demonstrate how the persistence of tinnitus is dependent on the aversive conditioned response continuing. As the patient will prove, the response can be retrained, and therefore the problem can be solved.

Why this model?

Used in this way, the Jastreboff model can demystify the whole unpleasant experience of the patient's tinnitus. However, once a flaw is found in the explanation, the whole model may be rejected. Therefore the model used with the patient should have the highest degree of compatibility with the physiological processes involved. In 8 years of using the model in this way not a single patient, having understood the model, has been left with an unanswered question. Beforehand it was common place to say 'we just don't know'. It does not make sense to use another model or different illustrations, which have inaccuracies, and which will not satisfy the patient's need for an detailed explanation of their experiences.

Counselling and teaching in different treatment categories

While the basic concepts of auditory function and the neurophysiological model need to be known by everyone, the emphasis may change. In hyperacusis, without tinnitus, (category (3)) the source of the aversive stimulus is outside in the environment, rather than neuronal activity in the brain. However the same process of pattern recognition and enhancement can occur, as with tinnitus. The problem is often compounded by the individual's attempt to block out sound, either by living in very quiet rooms, or with ear plugs or muffs. This leads to further auditory gain and amplification of external sounds, so that when they are heard they are much louder than normal. This is the reason for decreased LDLs. Increasing loudness perception then creates an aversive reaction to the sound. This may be strengthened by worries that sound may be damaging the ear, because it is perceived as being over loud. Discussion about tinnitus sources and processing mechanisms can be left out in this category.

In category (4) patients there is a 'kindling' phenomenon, in which the enhancement of external

sounds, and tinnitus, is made worse by exposure to (normal) environmental sounds, for periods longer than 24 hours, or a good night's sleep. Pathological processes in subcortical auditory pathways are responsible for this phenomenon, which is relatively rare. It creates the hardest-to-treat group, requiring extended treatment both with counselling and sound therapy. Such patients can be made much worse by other therapies involving altered music, and 'pink noise', set to unmonitored levels.

Where phonophobia occurs in category (3), and in almost all patients in category (4), there is a phobic reaction to certain sounds. Percussive sounds are frequently disliked, but traffic sounds, kitchen noises, and even rustling paper can evoke a powerful aversive reaction. Counselling stresses the importance of very gradual reintroduction of these sounds, while reactions are suppressed. It is hard to persuade someone fearful of damage to the ear, with worsening sensitivity, to practise this technique, unless they can understand and believe the model.

Children

Children as young as 4 years have been successfully treated with TRT. The model has to be kept simple, as well as the drawings and parables used to illustrate the child's experience. The parents must be included, as it is often their anxiety about symptoms, rather than the child's, that keeps the reaction going. Children are very compliant about instrument use, easily accept new beliefs and ideas, and because of a high level of brain plasticity (necessarily for TRT to work), improve more quickly than adults and need fewer visits.

Sound therapy – avoidance of silence

The auditory system has developed, in nature, in an environment of continuous background noise. While such nature sounds tend to create a feeling of relaxation, many of the sounds generated by industry, traffic and other machinery, are unwelcome. The ability to isolate our environment from external sound by double window glazing etc. allows much of the day and general all the night-time, to be passed in near silence. This results in abnormal increases in central auditory gain. If a search by pattern recognition processes in the subcortex for external stimuli is unsuccessful, then the sensitivity of detection increases. Consequently when environmental sounds are finally encountered they are unnaturally loud, to the point where they cause distress. The same process of enhancement works with tinnitus pattern recognition, hence the reasons for the Heller and Bergman phenomenon [3]. Patients need to learn by this information, that silence is actually harmful to them, although quietness is not. The environment needs to be enriched with sound on a 24-hour basis, but this must be with sounds that are not themselves likely to create further aversion or dislike. Selecting suitable sounds for enrichment is not a trivial process. Advice such

as 'leave the TV on' is quite inadequate. Nature sounds are best, like moving air (from a fan), water (from a waterfall) or good quality recordings. Music, radio and TV should only be turned on when it is wanted for its own sake. Some of the latest electronic sound enrichment devices work very well. At night enriching sounds must not disturb patient or partner. Night-time enrichment is necessary because the subconscious pathways are active during sleep, and waking with tinnitus (or hyperacusis) at night is much more likely in a silent environment.

The use of earplugs and muffs must be gradually withdrawn and aversive sounds slowly introduced. At no time should any change in sound environment result in a worsening of the patient's reaction to sound. If this occurs then the speed of change is too great. Patients in category (2) (with hearing aids) need to be instructed in the use of sound enrichment, as if they had normal hearing.

Patients in Category (0) have mild symptoms of tinnitus, without a significant aversive reaction. They are given an initial retraining/directive counselling session, with instruction about sound enrichment. They are not fitted with instruments. A follow-up appointment is made for 6 months. Patients who are not improved, or request more help, can be moved into category (1), and formal TRT restarted.

The use of instruments

Wide band noise generators (WNG) which look like are small hearing aids are fitted post-aurally or sometimes in-the-ear. Fitting must be binaural and non-occlusive, to avoid reducing ambient sound. Non-occlusion is important to avoid a reduction in ambient sound resulting in an enhancement of tinnitus perception. This can also temporarily reduce hearing in noise. For this reason post-aural fittings on open moulds are most often recommended. The purpose of wide band noise generators is:

- to enhance background sound, and avoid silence;
- to provide a constant broad band of sound to both ears which is itself quickly habituated;
- to increase plasticity in sub-awareness neuronal networks concerned with pattern recognition, and their connections with limbic and autonomic systems;
- to reduce the impact of tinnitus or aversive external sounds (in hyperacusis) without masking them;
- to reduce gain (amplifying effect) in central auditory pathways.

Broad band noise is preferred as it stimulates auditory neurones regardless of their characteristic frequency and is more easily tolerated and habituated than narrow-band noise. Binaural fitting is necessary to avoid asymmetrical stimulation of the auditory system, which itself can cause tinnitus enhancement. Frequency specific sound therapy is always inappropriate.

Instruments need to be fitted by properly trained audiologists. The method can only be briefly outlined here. WNGs must be comfortable to wear, and the volume control must be sensitive, particularly close to zero.

In category (1) patients, the volume is set close to the 'mixing point' with the tinnitus (Figure 4).

The WNG must never itself produce discomfort or aversion, if this occurs the volume is set too high. It must never alter the perceived characteristics of the tinnitus, although it may reduce its perceived loudness and therefore its impact. It must never mask the tinnitus, as this inhibits habituation, which cannot occur in the absence of the sound-to-be-habituated.

In category (3) patients, the introduction of wide band noise is very gradual, beginning just above threshold and slowly increasing the volume over days or even weeks, to achieve a reduction in abnormal central auditory gain (hyperacusis). Many patients experience some immediate relief of hyperacusis symptoms once instruments are fitted, and ambient sound avoidance with earplugs or muffs has been abandoned.

In category (4) patients, the application of wide band noise has to be even slower, over weeks or months. Failure to do this may result in kindling or 'winding up' of auditory gain, and worsening of symptoms. This is the hardest group to treat, and takes the longest time.

Category (2) patients (significant hearing loss), should be fitted with binaural aids whenever possible and practical. Only 'best practice' fitting will achieve optimal results. Patients must be advised to use sound enrichment at all times.

Retraining exercises

As the aversion to tinnitus is frequently started by classification of tinnitus as a negative event, reclassification or re-evaluation is essential. Frequent reaffirmation of the neurophysiological model, knowledge of the Heller and Bergman phenomenon, and the normality and commonplace of tinnitus emergence, should gradually evoke a different pattern of thinking about tinnitus. It is no longer understood to be a dreaded affliction, but simply 'the music of the brain', and shared by everyone.

It is helpful to spend several short periods of time each day listening to tinnitus (or in the case of hyperacusis, external sounds), without reacting, at first for seconds, later minutes. This is an exercise in diplomacy, in which the concept of tinnitus as an unwelcome guest is gradually changed to one of an old friend. Severely aversive and reactive patients cannot do this to begin with. The professional in charge should carefully monitor this exercise.

Adjunctive therapies

Any treatment, which is effective in reducing autonomic activity, such as relaxation training,

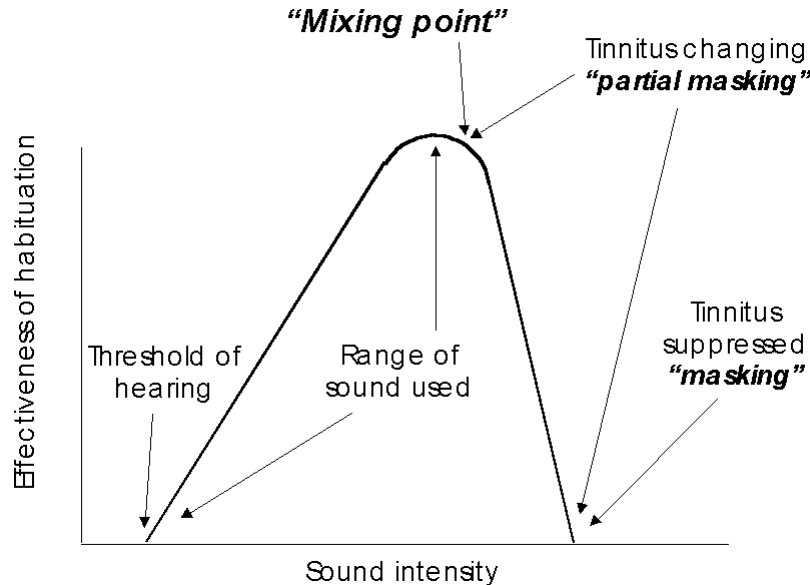


Figure 4 The effectiveness of wide-band noise generators increases as volume is increased towards the mixing point. Once tinnitus is altered or masking begins, effectiveness rapidly reduces

bio-feedback, yoga, and many other alternative therapies, can have a temporary beneficial effect. They work by reducing part of any reactive or aversive process. However they are not specific to tinnitus and hyperacusis, and will not produce a long-term effect unless TRT is applied as well. Relaxation techniques are particularly effective if used in conjunction with the listening exercise described above.

Follow up

Follow up of all patients is essential. In Category (0) patients, one visit is planned to check progress. All categories are advised to come back if a problem recurs. It is advisable to see all severely affected patients one month after the first visit, when doubts about TRT effectiveness can be experienced after initial gains. TRT takes on average 1.5 to 2.5 years to reach a significant and maintained improvement. The number of visits needed varies between 2 and 12. The visits are shared between medical otologist, and audiologist/therapist.

The team

The minimum requirements are for a medically qualified otologist or audiologist, plus an audiologist/therapist able to do instrument fittings, and make measurements. Both should be trained in TRT methods. It is advisable to have access to colleagues in psychology and psychiatry to help with very disturbed patients and other problems apart from tinnitus and hyperacusis that may require treatment. The exact nature and composition of the team will vary according to training and personnel in different departments and in different countries.

Preventative measures

An important part of any TRT program is making all health-care professionals aware of the basic mechanisms of tinnitus and hyperacusis, and to avoid negative counselling, particularly in primary care. Nearly all our patients have either been made worse by inappropriate counselling, or in many cases would not have begun the aversive reaction without receiving negative information about tinnitus. Patient organisations and self-help groups can assist in this process.

Training of professionals

As TRT becomes established, and increasing evidence emerges of its widespread effectiveness compared to other techniques, proper courses need to be established to train those individuals who, in practice, meet tinnitus patients day by day. Experience shows that motivated professionals can learn the basics of TRT in a short intensive course [4], and become effective in using it after 6 months' to 1 year's practice. However, like the practice of audiology itself, the effective management of tinnitus and hyperacusis by TRT can take years to perfect.

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