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# TINNITUS RETRAINING THERAPY BASED ON THE JASTREBOFF MODEL

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## How we hear

Conscious awareness of sound takes place near the surface of the brain when a pattern of electrical activity travelling up the nerve of hearing from the ear reaches a point just below the auditory cortex. (Figure 1) The hearing nerve has about 30,000 different fibres, and patterns of electrical activity in these fibres are matched with other patterns which are held in the auditory or hearing memory. The cochlea, or inner ear which changes sound waves into these electrical patterns is a surprisingly noisy place, where continuous mechanical and electrical activity in 17,000 hair cells can now be monitored with sensitive, computer enhanced, listening devices

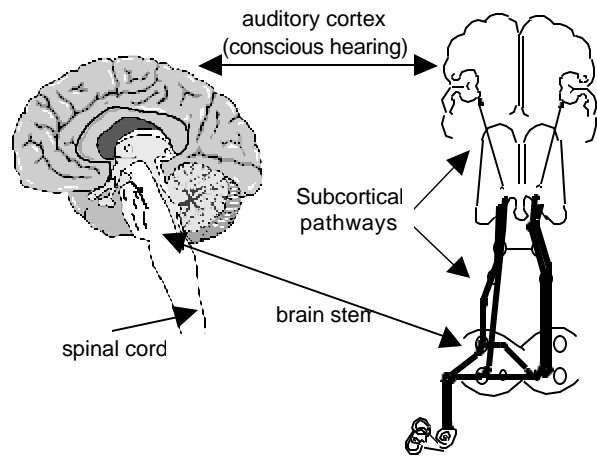


Figure 1 *Nothing is heard until sound patterns, generated in the cochlea, reach the cortex of the brain*

Most of what we hear is a sequence of sounds, like speech or music. In infancy, new sound experiences are stored in an information hungry but relatively empty auditory cortex. Later on there is a continuous process of matching familiar memory patterns with those coming from the ear. Each time a pattern from the ears is matched with a pattern in the auditory memory we have the experience of hearing a sound.

Putting together these matched patterns starts a process of evaluation. Another part of the brain close to the hearing centre is involved in the *meaning* of what we hear, and in interpreting the language. If it's a foreign language we can hear the sound but may not understand the meaning.

## The meaning of sound

Sound is of enormous importance in monitoring our environment. Hearing in animals (who are constantly in fear of their lives because of attacks from predators) has to be very sensitive and specific. The ability of animals to develop extremely acute hearing, by which they could detect the very small sounds of an attacker a long way off, contributed to the survival of that species. These warning signals produce acute anxiety, prompting appropriate action to avoid attack, the so- called survival reflex.

We respond in the same way to the sound of a motorcar horn, by automatically putting our foot back on the pavement or sidewalk. Some sounds can be identified as warning signals, while others can evoke a feeling of security or pleasure. We have this experience every day with sounds that alarm us, or sounds that soothe us such as music, or the sounds of nature.

## Conditioned responses

When a sound has special meaning, like the baby waking at night, or the creaking floor board, or the sound of first our name, we respond to it in an automatic manner. This happens after a short learning period, but the responses can remain as strong as ever throughout life. During sleep, the conscious part of the brain is 'shut down' so we don't hear, see or feel anything. However the mother still wakes to the baby stirring even though she has just slept through a thunder storm. (Maybe that's what woke the baby!).

This shows that weak patterns of sound, if of great meaning can be detected by *subconscious filters* (figure 2) in the hearing pathways, between ear and brain (auditory cortex).

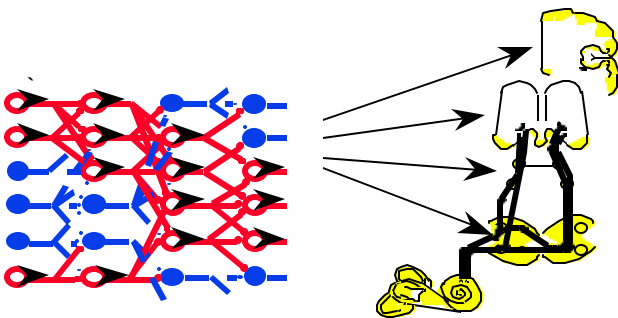


Figure 2. Between ear and brain there are 2M nerve cells forming a neuronal network, capable of sophisticated pattern recognition, enhancement and suppression of auditory signals.

The conditioned response also triggers activity *outside* the auditory system where there are

large numbers of connections with the *limbic system*, (figure 3) which is concerned with emotion and learning. Also activated is the *autonomic nervous system* which turns on the body's 'ignition key', to prepare for any eventuality, particularly 'fight or flight' and gets the body ready for action.

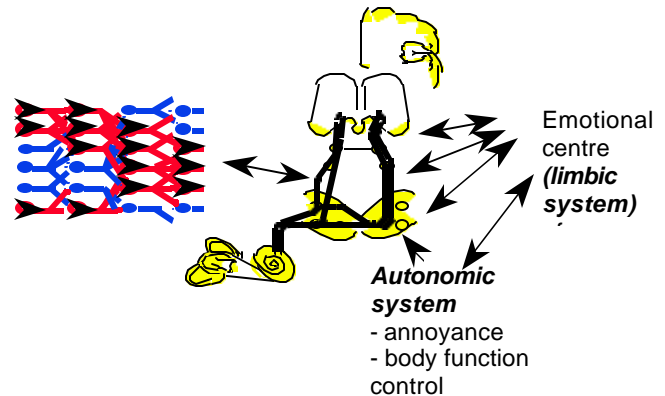


Figure 3 Neuronal networks between ear and brain detect threatening sounds and activate a reflex response involving fear/annoyance, and increase of body functions, to prepare for danger - the conditioned aversive response

High levels of autonomic function tense muscles, raise heart and breathing rates, cause sweating, and are the *complete opposite* to the state of relaxation. They rightly preclude sleep, or concentration on other, less important tasks. Most of our day to day activity consists of a series of conditioned responses, executed to order. Other examples of conditioned responses include the famous Pavlov dog experiment. So, each and every sound that we hear and learn the meaning of, has an "emotional label" attached to it, which may change from time to time according to how we feel in ourselves and the context in which we hear it. For example the sound of a neighbour's television set may be acceptable, or unpleasant and intrusive, depending on whether it belongs to a well loved friend or relation, or somebody else who for various reasons we dislike.

## The meaning of tinnitus sounds

In 1953 Heller and Bergman performed an simple and classic experiment. They placed 80 normally hearing and tinnitus free individuals (university students) in a sound proofed room for 5 minutes each, asking them to report on any sounds that might be heard. The subjects thought they might be undergoing a hearing test, but actually experienced 5 minutes of total silence. 93% reported hearing buzzing, pulsing, whistling sounds in the head or ears *identical* to those reported by tinnitus sufferers.

This simple experiment enables almost anyone to detect the background electrical activity present in every living nerve cell in the hearing pathways as a sound. Although some areas of the auditory system may be more active than others, every neurone will contribute *to some extent* to the final perception of tinnitus. Its good to think of the sound heard in the Heller and Bergman experiment as '*the music of the brain*'.

Of those who DO experience tinnitus, epidemiological research shows that about 85% do not find it intrusive, disturbing or anxiety provoking (something tinnitus sufferers find very hard to believe!). The reason for this is not so much because the quality or loudness of the tinnitus is different; in fact we have found that tinnitus is of a very similar type of sound in those who are bothered by it and those who are not. The main difference is that those who find tinnitus troublesome, evaluate and perceive it as a threat, or at the very least an annoyance, rather than something of little or no consequence.

Just as the animal alerted to danger by the sound of a predator focuses solely on that sound in order to survive, so those who consider that tinnitus is a threat or warning signal are unable to do anything but listen to it. It is part of the mechanism that humans have developed for self preservation, although clearly in this situation it is not working to our advantage! Many people

complain of the loss of silence, something they previously greatly treasured and enjoyed, before tinnitus became persistent.

## Persistent tinnitus depends on a conditioned response

So what happens, even in mild cases of persistant irritating tinnitus, is that a conditioned response (reaction) is set up to the tinnitus sound (the sound evoked by background electrical activity in auditory nerve cells). As this conditioned response occurs in the subconscious part of the brain, what you may be thinking about tinnitus at any time, (or even if you're not thinking about it), is irrelevant to the reaction produced.

Moreover, it is the reaction to tinnitus which is important in creating distress. That is, the degree to which unpleasant feelings about it (from the limbic system) and increased tension (from autonomic system stimulation) are experienced, every time the tinnitus signal is detected. This mechanism is graphically illustrated by the Jastreboff model (figure 4)

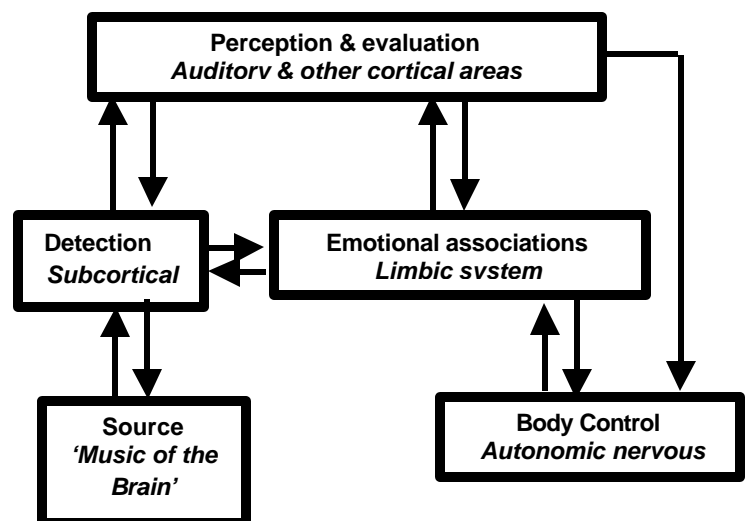


Figure 4 The Jastreboff Neurophysiological Model of Tinnitus (1995)

## **Tinnitus as a new experience**

When tinnitus first emerges it is a new signal, there are no memory patterns, and no means of categorizing it. Any new experience tends to produce a feeling of discomfort, due to a loss of the 'status quo' and a change in what was previously a stable environment (a change in 'homeostasis'). Until proper evaluation has been undertaken of what tinnitus means, it will be regarded with understandable suspicion. Many 'sufferers' only experience mild annoyance from tinnitus as a result of this mechanism, but it may be sufficient to promote the need to seek help.

## **Tinnitus as a threat**

For many sufferers, tinnitus is quite threatening. Some people fear that tinnitus means they have some kind of serious illness. Others are convinced that the experience of 'disco tinnitus' means permanent damage to the ear, rather than temporary protective 'shut down'. There are patients who worry about the possibility that it heralds a brain tumour, blood clot, or some serious mental illness ("it will drive me mad!") These anxieties are almost always unfounded. Many people fear that tinnitus will get louder, continue for ever, and cannot be cured. Even the concept that tinnitus is invading one's 'right to silence' constitutes a threat, very similar to the territorial invasions that animals experience. It is often feared that tinnitus will continue to spoil peace and quiet, interfere with concentration at work, quiet recreational activity and ability to sleep at night.

Unfortunately these fears may be enhanced by professional advice, or reports from others of their own, phobic reaction to tinnitus. Many doctors and other professionals still advise patients that there is nothing that can be done about tinnitus and that it will go on for ever. Other people fear that tinnitus may mean that

their hearing is becoming impaired. Tinnitus may be the consequence of a mild hearing impairment rather than the other way around, but is still only twice as common in hearing impairment to normal hearing. In any event the threatening qualities of the tinnitus are enhanced.

Finally many tinnitus sufferers are angry about the treatment, or lack of treatment, or inappropriate advice that they have received. They may feel guilty for having submitted to treatment which they think is the cause of their tinnitus. Fear, anger and guilt are very powerful emotions which are intended to enhance survival-style, conditioned, reflex activity, and consequently greatly increase attention on the tinnitus. In our experience, tinnitus improves when the patient overcomes these feelings and stops dwelling on thoughts of injustice.

## **Tinnitus as a phobic state**

In some patients extreme fear of tinnitus results in a phobic state developing, very similar to that of the fear of spiders, frogs, small spaces, flying etc. Many tinnitus sufferers also have these phobias, suggesting common mechanisms at work. In any phobic state a slow process of 'desensitisation' has to be used, confronting the feared object, and learning first to tolerate it, and then to accept it as a normal phenomenon that does not in any way threaten. Many aspects of tinnitus retraining are common to these techniques.

In many people the response to tinnitus is milder, though still negative in its meaning. Annoyance or ill-ease exists, and although strong emotions may not be evoked, the limbic and autonomic systems are still being stimulated to produce aversive and intrusive emotions which reduce life quality. These qualities of tinnitus, which make people seek help, are created *outside* the hearing mechanism, and therefore cannot be helped by a purely audiological or ear-related approach.

## Tinnitus Retraining Therapy

Successful tinnitus management in our clinics is a result of retraining and relearning. Once the tinnitus loses its sinister meaning, however loud it has been or however unpleasant it may seem, it DOES begin to diminish, and in many cases may not be heard for long periods of time. In most cases firmly held beliefs are hard to change.

**Retraining** the *subconscious* auditory system to accept tinnitus as something that occurs naturally, does not spell a lifetime of torture and despair, and is not a threat or a warning signal, can take months and sometimes even years. Such retraining should be guided by professionals with experience in this field forming part of a multi-disciplinary team. For people who also have co-existing or pre-existing anxiety or depression it can take longer to change their feelings about their tinnitus.

When we talk about retraining, this is not simply an abstract learning exercise. In the subconscious part of the brain concerned with hearing, beyond the inner ear, but before the act of conscious perception of sound takes place, subconscious filters (figure 2), networks of nerve cells (neuronal networks) are programmed to pick up signals on a 'need to hear' basis.

Think again of the way we invariably detect the sound of our own name, or a distant car horn, or a new baby stirring in sleep, whereas we may be unaware of the sound of rain pounding on the roof or surf beating on a sea shore. Retraining therapy involves reprogramming or resetting these networks which are selectively picking up 'the music of the brain' in the auditory system. Although these are 'nature sounds', they become a problem because they have been identified as a threat, either to life, or life quality.

Tinnitus retraining first involves learning about what is actually causing the tinnitus. This begins with proper examination by an ear specialist followed by a full explanation of what is going on in the ear and the brain to produce the tinnitus sound. However specialists who themselves believe that tinnitus is an 'ear' phenomenon cannot help. We are in a difficult situation where the classical training of tinnitus being due to inner ear damage is still very dominant, rather than an understanding based on the neurophysiological model (Jastreboff P.J. 1990) – figure 4. You may have experienced this visiting other tinnitus sites or user groups on the internet.

We need to learn that the sounds of tinnitus which we may interpret as distressing, affecting life quality, and seemingly unending, are, in reality the sounds of nature, coming from weak electrical signals in the auditory pathways which have always been there. With appropriate directive counselling (or 'retraining') from professionals, we can change even strongly held views that tinnitus is a threatening and unpleasant experience which cannot be altered.

## Habituation of reaction and perception

The presence of any continuous stimulus usually results in a process called habituation, whereby the individual responds less and less to the stimulus as long as it does not have any special negative meaning. The final stage in this process is when the signal is no longer detected, and cortical neurones are unresponsive. With tinnitus this means that it is no longer heard, even if it is listened for.

Retraining therapy can achieve this. As the process takes a long time (often 2 years or so), during the initial stages tinnitus becomes gradually less unpleasant (but may still be perceived as a loud sound). This process is called **habituation of reaction**. Tinnitus then becomes quieter for longer periods of time, and

eventually disappears or becomes a natural part of the background 'sound of silence' (**habituation of perception**). This cannot happen, however, while tinnitus is still classified as a threat, or negative experience, that demands further monitoring

## Hearing loss and tinnitus

One way in which the ear itself *does* contribute to tinnitus is if there is a hearing loss. This may be quite slight, or just in the high frequencies. Any tendency to 'straining to hear' can increase amplification of sound signals in the subconscious part of the brain, and increase the ease by which tinnitus signals can be picked up. This is why it is important to correct any significant hearing loss with appropriate hearing aids, as part of overall tinnitus management. However, inept and inappropriate hearing aid fitting by those unpracticed in tinnitus management can make it worse, a frequent finding in our tinnitus clinic.

In some cases changes in inner ear function may be important in triggering tinnitus emergence (e.g. Menieres disease or acute acoustic trauma), however ***the retraining approach works independently of the trigger factor***.

It is important to distinguish between the role of the ear in the EMERGENCE of tinnitus (e.g. disco tinnitus) and the role of central processing in the brain, outside the auditory system, in the determining PERSISTENCE of tinnitus and our emotional response to it.

Despite the importance of hearing loss a recent study of our tinnitus clinic patients showed there was no significant difference in hearing between the tinnitus group and normal population statistics .

## Wide band noise generators (WNGs)

Wide band noise generators (previously called 'maskers'), have a different role to play. Tinnitus masking was at one time thought to be useful in

that it simply made tinnitus inaudible. In fact this proved to be counter-productive, as tinnitus, the object of an exercise in habituation, must be audible for habituation to occur. Habituation to any signal cannot occur in the absence of its perception. Imagine trying to habituate your response to spiders, which you hate, simply by avoiding them.

Much better long-term results can be obtained if wide band noise is used at low intensities while the tinnitus can be heard at the same time. Wide band noise contains all frequencies, and therefore very gently stimulates all the nerve cells in these subconscious networks, allowing them to be more easily programmed, or reset, so that tinnitus signals are no longer detected. It also reduces the contrast between tinnitus and otherwise total silence. WNGs on their own may give a temporary reduction in distress from tinnitus, but will not achieve long-term habituation without the other essential elements of TRT - teaching - demystification - re-evaluation - desensitisation.

## Silence may not be golden

Emergence of tinnitus is often dependent on silence. Most tinnitus is first heard at night in a well sound-proofed bedroom, or a quiet living room (Heller and Bergman 1953). Persistence of tinnitus depends on the meaning attached to it, but also to the contrast it creates with the auditory environment. Contrast contributes greatly to the intensity of any perception. Thus a small candle in the corner of a large darkened room seems dazzlingly bright until flood lights are switched on making it virtually invisible. Tinnitus patients should avoid extreme silence, and retraining programmes will often use wide band noise therapy as a means to reduce this contrast. In all cases SOUND ENRICHMENT should be practised. Make sure there is always a pleasant, non-intrusive background sound (like a large slow fan, or an open window). Choosing what is right for you may take some time. Avoid masking tinnitus, but have some sound present

during day and night. It is essential that enriching sounds do not themselves cause irritation to patient (or partner), or habituation will be slowed down.

Many tinnitus patients have hyperacusis (sensitivity to external noise) and for this reason often seek very quiet environments. In this respect they are their own worst enemy! (see [www.tinnitus.org](http://www.tinnitus.org) for information on this). In all cases sound enrichment should be practised, using unobtrusive sound sources (e.g. a domestic fan, an open window), to break the silence.

Remember that although using wide band noise on its own can give some temporary relief from tinnitus discomfort, unless it is combined with the retraining approach, there is very little chance of permanent relief. Information, teaching and *demystification* about tinnitus and tinnitus mechanisms are the most vital parts of the therapy. It is particularly encouraging to receive email from tinnitus sufferers, who have obtained relief simply from reading these pages on a regular basis.

Otherwise where strong beliefs about the threatening nature of tinnitus are maintained, the survival-style conditioned response mechanisms in the subconscious brain ensure that it is continuously monitored.

At the present moment TRT is available in relatively few centres, but the techniques are spreading and gradually being learned and used in an increasing number of otology and audiology departments around the world.

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**This handout is for the benefit of patients with tinnitus, and their friends and families. It may be distributed freely, as long as it is not altered in any way. JWP.**