

## HYPERSENSITIVITY OF HEARING (Hyperacusis, misophonia, phonophobia and recruitment - decreased sound tolerance)

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Continuous and loud noise is a source of irritation to most people. However some people have especially sensitive hearing and are unable to tolerate ordinary levels of noise. This can occur in people with normal hearing, or in those with a hearing loss. There are three components which can contribute to sensitive hearing hyperacusis, phonophobia and recruitment. Our knowledge based on the [Jastreboff model](#) and desensitization techniques developed in the 1980s (now allows effective treatment of hyperacusis and misophonia.

### **The mechanisms of hyperacusis, misophonia, phonophobia and recruitment.**

Hyperacusis is due to an alteration in the *central processing* of sound, and the cochlea is often completely normal, although patients frequently wrongly believe it is irreversibly damaged. The traditional teaching involves only an understanding of 'recruitment', the result of cochlea damage. Since almost all people with hyperacusis can be helped by behavioural and 'sound' therapy, it has become clear to us that the symptoms cannot be the result of irreversible ear damage. People with hyperacusis also often have *misophonia*. This means a dislike of being exposed to a certain sound, sometimes because of the belief that it will damage the ear. If this dislike is very strong we may call it '*phonophobia*' literally - fear of sound. Often these are normal environmental sounds like traffic, kitchen sounds, doors closing, or even loud speech, which cannot under any circumstances be damaging. In *misophonia* certain complex sounds produce discomfort, on the basis of their meaning or association, but other sounds which are enjoyed

(such as music) can be tolerated at much higher levels. If there is a difference in the intensity of different sounds which produce discomfort, then it is very likely that a degree of misophonia exists. Misophonia can lead to hyperacusis (changes in central auditory processing), and a consequent persistence of abnormal loudness perception. In practice, most people with hypersensitivity to environmental sound have both hyperacusis and phonophobia together in varying proportions. In treating these conditions, it is important to diagnose which condition is present and which is dominant.

A common widespread and largely harmless expression of misophonia is seen in the fathers of teenage children to 'modern' music being played (even in the distance) and to the dislike for music 'leaking' from the headphones of portable cassette players on public transport. In addition some sounds are inherently unpleasant, like the squeak of chalk on a slate, even though the number of decibels produced by this is very small. This is 'cultural' or species phonophobia!

### **Recruitment**

A normal ear is able not only to hear extremely quiet sounds (between 0 and 20dB hearing level) but can also tolerate very loud sound without discomfort (up to levels of 115dB hearing level). With hearing loss an inability to hear quiet sounds may be coupled with a paradoxical intolerance for loud sounds due to *recruitment*. An ear with recruitment might well be unable to hear sounds, particularly high frequency sounds, below 50dB, but find any sounds above 80dB not only uncomfortable but liable to produce distortion. Recruitment is due to a reduction in neural elements in the inner ear (usually the outer-hair cells), so that a small change in stimulus intensity produces a bigger change in response of the inner ear. More nerve fibres are switched on or 'recruited', for a corresponding sound stimulus. Another way to look at this problem is to consider the ear rather like a musical instrument. Nevertheless many people, perhaps the majority, who have hypersensitivity and hearing loss, have hyperacusis rather than recruitment, or may have some degree of both. Even if recruitment exists it is possible to retrain the brain (central processing) to alter its appreciation of loudness and accommodate the smaller dynamic range of

the hearing impaired, and recruiting cochlea. Where the hearing is normal, or near normal hypersensitivity is always due to hyperacusis (plus or minus misophonia) and NEVER due to recruitment. This concept may represent a fundamental change of thinking to traditional views given by many health care professionals.

### Mechanisms of hyperacusis

The brain plays a big part in sensitivity to sound. When sounds reach the inner ear, they are coded into their individual frequency components. The 30,000 fibres in the auditory nerve carry information about the individual frequencies of each complex sound that we hear and 1/20 of a second later, these reach the cortex of the hearing part of the brain (in the temporal lobe) where conscious perception of organised sound occurs. Until the message reaches consciousness, no sound is heard. During the passage of this coded signal it undergoes a great deal of processing, similar to a computer, but much more complex.

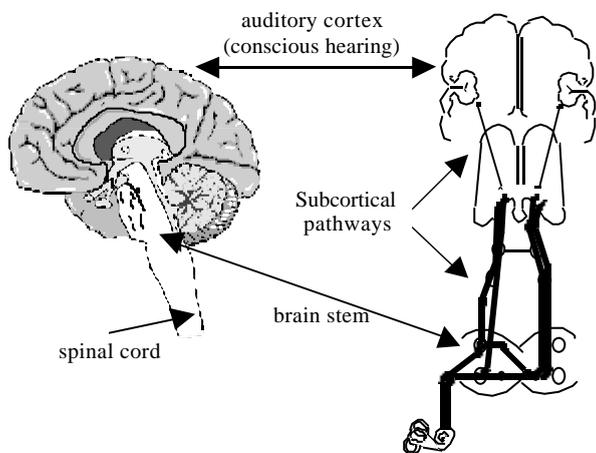


Figure 1. *Nothing is heard until sound patterns, generated in the cochlea, reach the cortex of the brain*

The central auditory system is first of all concerned with extracting important messages from unimportant background noise. Often the signal is relatively weak in strength, but strong in meaning. An example of this would be the detection of the quiet sound of a predator by an animal living in a hostile environment. Another example would be the ability to detect the sound of one's name across a crowded room, while

other names, even if spoken quite loudly would go unnoticed.

In the subconscious part of the brain, an important signal is detected on the basis of previously learnt experience. This signal may then be enhanced, and its passage facilitated in nerve pathways. These pathways are not inert electrical cables, but complex neuronal or nerve networks which work by changing electrical resistance between nerve cells in the pathway. This is somewhat similar to the switching that occurs in the telephone exchange to allow one person to speak to another. When the enhanced signal reaches the cortical level of sound awareness, the electrical pattern representing many different frequencies (pitches or musical notes) has to be matched with another pattern that is held in our hearing memory. This 'pattern-matching' event may be very weak, resulting in a weak perception of sound. A strong pattern match results in a loud and intrusive sound perception. The strength of pattern matching and consequent sound perception is governed by the limbic system (the centre of emotion and learning). The original purpose of this ability to amplify small signals and to suppress others was to facilitate the detection of potential threats in the environment.

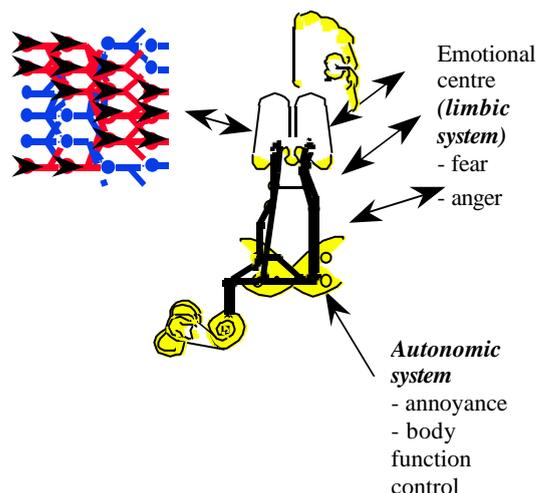


Figure 2 *Neuronal networks between ear and brain detect threatening sounds and activate a reflex response involving fear/annoyance, and increase of body functions, to prepare for danger*

## The Meaning of Loudness

Under normal circumstances we hear more intense sounds as seeming louder than quiet sounds, but our perception of loudness is not dictated simply by the strength or intensity of the sound arriving at the ear. Some sounds become loud, intrusive and unpleasant because of their meaning or association. This is almost universally true for the sound created by scratching chalk on a slate, or the sound of a burglar alarm down the street. In most cases, the association has some threatening qualities; Will the sound damage the ears? Will it disturb sleep? Will it reduce life quality by reducing periods of quiet recreation? Will it interfere with concentration?

Very often the over-sensitivity for sounds is begun by an irrational fear which nevertheless becomes a very strongly held belief. This is commonly the source of distress in those who believe that their lives are ruined by environmental noise from nearby factories, generators or low frequency sounds transmitted through the ground (which other people may be unable to hear). Because the central auditory processing mechanism is so powerful, it is possible to "train" it by constantly listening to, and monitoring small sounds. These weak sounds are turned them into very loud intrusive and unpleasant *perceptions* which become constantly audible whether we like it or not.

## Hearing tests

The standard 'pure tone audiogram' measures the quietest sound you can hear. You listen through headphones to sounds from a carefully calibrated instrument (audiometer), and respond (e.g. by pressing a button) whenever you hear a sound, however quiet. This is called the *threshold* of hearing. An equally important, but less frequently used test measures the upper limit of loudness tolerance. You should indicate when the tones become uncomfortable to the ear (before they become painful). For patients who are frightened of loud sounds this test must be done carefully and with proper instruction. None of the sounds from the audiometer are capable of damaging the ear, even in a sensitive individual. It is very important to have a good knowledge of the level of loud sound tolerance

when treating hyperacusis, or when fitting a hearing aid to any patient, whether they have hyperacusis or not.

## The Limbic System and Emotional Responses

Changes in emotional state, particularly mood fluctuations or anxiety can increase overall arousal and make us more able to detect potential threats in our environment. This is a normal protective mechanism. These emotional changes can increase the apparent loudness and irritation of sounds to which we are already hypersensitive. In some people this results in a "global" hypersensitivity where all stimuli, whether they be visual, auditory, olfactory (smell), taste or touch and pain are increased greatly in their perceived intensity.

The process of developing an increased sensitivity to sound always involves the limbic system and autonomic nervous system. Where phonophobia already exists its not difficult to understand the inevitable association of fear, anger, or irritation with the appearance of the sound whenever it occurs.

However in any situation where there is hyperacusis, a state of increased arousal is induced, because of the enhancement of sound by the central auditory pathways. The attentional focus becomes filled with sound, so that interference with concentration (on another task) occurs. The repeated appearance of sound which indicates annoyance, anger or fear, results in the establishment of a subconscious *reflex* response with automatic and invariable stimulation of the limbic and autonomic nervous system . Exactly the same reactions of the nervous system occur naturally when we automatically take our foot out of the road we are about to cross on hearing a car horn, only to discover the car is disappearing in the other direction! Protective reflexes have to carry a message of unpleasant emotion, in order to ensure that a response occurs. They also stimulate the autonomic nervous system to prepare us for 'flight or fight' so there may be coincident increases in heart rate, sweating, muscle tension, and other adrenaline-mediated body responses. Check Figure 2 again.

## Treatment of Hyperacusis

### With hearing loss

Where there is a hearing loss and a need for a hearing aid fitting, this must be done without overloading the ear with amplified sound. Many hearing aids have some form of compression, which stops loud sounds entering the hearing aid from being over-amplified. Automatic volume control is available on most hearing aids and non-linear compression is a more advanced type, that may help some hearing impaired people with hyperacusis and/or recruitment. Programmable hearing aids frequently make the task of appropriate hearing aid fitting easier.

In fitting hearing aids to sensitive ears, it is best to leave the ear canal as un-occluded as possible, particularly to begin with. Where there is simply a relatively small high frequency hearing loss, an "open" mould should be used. Where more amplification is needed, the mould should be vented to allow the escape of unwanted high levels of low frequency sound. Trials with different sorts of ear moulds can often be very helpful.

### Avoidance of silence

Many people seek silence as a way to escape from the pressures of everyday life. However complete silence is not found in nature, and should be considered 'unnatural'. Consider living in a nest or animal burrow! In the relative silence of houses with doubled-glazed windows, often hermetically sealed from the outside world, the absence of sound stimulation leads to an increase in central auditory gain or 'amplification'. The auditory filters 'open' in an attempt to monitor the external sound environment. External sounds may then increase dramatically in their relative intensity and intrusiveness. Those with long histories of disturbed sleep (often a symptom of mild depression, or anxiety dating from childhood) take to wearing earplugs to exclude disturbing external sounds to facilitate getting off to sleep. This further increases the effect of central auditory amplification. Some people with hyperacusis have a life-long aversion to sound intrusion of any kind. This may indicate a tendency to be easily threatened by external events. We have treated some patients who

were so frightened of sound as to have special sound-proofed rooms built in their houses, where they spent almost all their time. Try and work out whether this was helpful to these individuals in the long run, and what effect it had on their hyperacusis and phonophobia.

When hyperacusis develops there is a great temptation to plug the ear to exclude unwelcome sounds. **This is actually making things worse**, as it encourages further increase in the amplification of sounds on their way to the auditory (hearing) cortex. When these sounds are heard in the absence of plugs, their perceived loudness is greatly increased. The loudness of sound depends not on the strength of the signal leaving the ear, but on the electrical voltage or potential reaching the cortex of the brain, after auditory processing, and the relationship of that sound to the background. If the background is totally silent, any sound can be perceived as extremely loud.

In every case sound enrichment should be practiced, enhancing silent environments with pleasant nature sounds on a 24-hour basis. Please refer to the article, which tells you how to do it.

The first step we take in desensitization is a counselling, or retraining approach designed to remove the need to plug or otherwise protect the ear from normal levels of environmental sound.. It is understandably difficult to accept that sound which can be uncomfortable or even painful to the HEARING, can be quite harmless to the EAR. This counselling must be undertaken by professionals trained in TRT.

*Hearing conservation* remains important in proven damaging noise situations, (e.g. gunshot, discos, industrial machinery etc) and here appropriate protection with muffs or plugs is needed, but only when in these environments. Damage is related not only to the intensity of sound, but also to the duration of exposure, so careful calculations need to be made to establish who is really at risk.

### Wearable Sound Generators (WSGs)

Research in the 1980s (Hazell & Sheldrake 1991) has shown that the use of WSGs applied to the ear by a wearable sound generator can in

many cases help in the treatment of abnormal hypersensitivity of hearing. This is particularly true in the group who have normal or near normal hearing. WSGs need to be applied very gently and gradually to the ear beginning at a low level, and under the supervision of an audiologist with experience in this process of desensitisation and with training in TRT. The effect, which in some cases may be quite dramatic, results in a turning down of central auditory 'gain' and a reduced perception of loudness for previously distressing sounds. Over a period of months, due to changes in these auditory neuronal networks, there is a permanent change in loudness discomfort, which can be demonstrated by audiometric testing of loudness discomfort levels. In patients where a severe increase of symptoms occurs, which genuinely persists after a good night's sleep, very careful use of sound therapy needs to be applied, under the guidance of an experienced professional. In severe cases there must be a gradual transition from wearing ear plugs to using WSGs. Fortunately WSGs 'turn down' the amplification of external sounds, so many people can immediately tolerate sounds which previously were distressing. Never undertake any sound therapy without proper advice. Sound tapes - e.g. pink noise, can make certain hyperacusis and phonophobic patients considerably worse.

In each case carefully explanation of the mechanism of central processing must be given, so that individuals can understand and believe what has happened to them, and that the whole process is reversible with time, and the appropriate therapy.

Where misophonia (dislike) or phonophobia (fear of sound) exists, no permanent change in loudness discomfort can be achieved without a successful behavioural programme aimed at reversing inappropriate beliefs responsible for the conditioned aversive response. This is true for any phobia (e.g. claustrophobia, arachnophobia, fear of heights etc). Where there is an irrational fear that normal environmental noises may be damaging, it is important to "retrain" the auditory system both at a conscious and subconscious level to respond in more appropriate manner. This involves the examination and discussion of the reasons behind the development for the hypersensitivity

and the fears held by the individual, whether felt to be real or imaginary, about the effects of such noises and the strong emotions that they evoke. In many cases the fears will have begun, or have been enhanced by *inappropriate negative counselling*. This may come from professionals trained in 'conventional' outdated knowledge about central auditory processing, or from poorly written 'patient advice'. Much of what is passed around on the internet, for example, about hearing hypersensitivity is based on old wisdom, or 'old wives tales'!

The whole process of desensitization can take quite a long time, commonly six months to a year, but is achievable in most cases.

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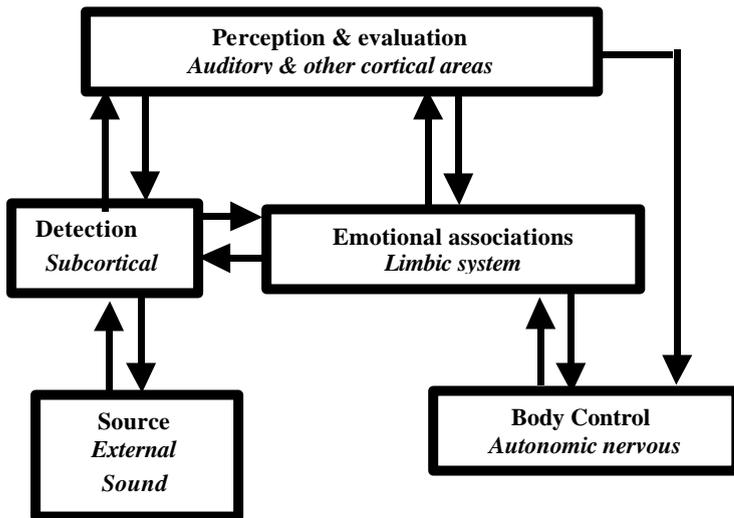
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*Jastreboff Model applied to hyperacusis and phonophobia*

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