WIDEX HIGH DEFINITION HEARING

WIDEXPRESS

NO. 27

FEBRUARY 2011

By: Anne Mette Kragh Jeppesen, MA
Hanne Pernille Andersen, MA, PhD

TINNITUS AND THE WIDEX ZEN PROGRAM

This article discusses how knowledge about tinnitus and tinnitus treatment can be used to develop a hearing aid that is able to address, not only hearing impairment, but also tinnitus issues.

Introduction

Surveys show that approximately one-third of all adults in the general population report experiencing some variety of tinnitus (McFerran et al., 2007), while among the hearing-impaired population, the proportion increases significantly to 70-85% (Martines et al., 2010). The high prevalence of tinnitus in the hearing-impaired population makes it highly relevant to focus on tinnitus management in addition to the amplification of sound.

What is tinnitus?

A review of the literature reveals that the precise nature and cause of tinnitus are much disputed. A universally accepted definition has not yet been achieved, but it seems that McFadden's definition from 1982 is widely accepted. His definition states that

- Tinnitus is a perception of sound (i.e. it must be heard)
- Tinnitus is involuntary (i.e. it is not produced intentionally)
- Tinnitus originates in the head (i.e. it does not involve hearing or being overly sensitive to an external sound)

(Cited in Tyler, 2005)

Another apparent factor is that the way in which the sound manifests itself differs from one person to another, and sometimes also from one situation to another. Tinnitus is therefore typically described as a ringing or buzzing sound, but other varieties can occur. The effect of tinnitus on the individual's life also varies, from no discomfort at all to a highly negative impact. In fact, it has been shown that while approximately 10% of all adults report long-term tinnitus, only 2-4% of the

adult population has been referred to clinics because of their tinnitus, and only 0.4% reports that tinnitus affects their quality of life (McFerran et al., 2007). In a few cases, tinnitus may be a sign of organic pathology and medical problems. It is therefore important that tinnitus patients receive a thorough medical evaluation to rule out a serious or treatable disorder. Usually, however, tinnitus is a sound without identifiable origins.

The cause of tinnitus

For the purpose of determining the cause of tinnitus, various neurophysiological models have been proposed to account for its origin. It is generally accepted in these models that tinnitus involves some kind of neural activity that is interpreted by the brain as sound, but the origin of this spontaneous activity is widely disputed. It has been suggested that tinnitus occurs because the auditive system misinterprets small internal signals (Heller et al., 1953). Others take the view that tinnitus results from an automatic gain control system in the central nervous system which causes sensitivity to increase in the absence of sound (Hazell, 1987). Yet others have suggested that tinnitus has to do with spontaneous otoacoustic emissions (Penner et al., 1989). Jastreboff considers tinnitus to be due to discordant damage of inner and outer hair cells (Jastreboff, 1990). Salvi et al. believe that brain plasticity may play a role, in that an unorganized reorganization associated with peripheral hearing loss will result in tinnitus (Salvi et al., 2000), while Kaltenbach et al. believe that tinnitus is caused by hyperactivity in the dorsal cochlear nucleus (Kaltenbach, 2004, Kaltenbach, 2005). The lack of consensus regarding the origin of tinnitus is clear from this subset of the existing neurophysiological models.

Since the cause of tinnitus is uncertain, and the effects are highly individual, it is necessary to include the individual's reactions to tinnitus in any model that attempts to provide an account of tinnitus. Several researchers have therefore proposed neurophysiological models that include the central part of the auditory system. Fig. 1 shows an example of such a model. In this model, the tinnitus sound originates either at the eardrum, the ossicles, the cochlea or the brainstem. The sound is registered in the box labelled 'filtering and pattern recognition'. If the sound is recognized and not considered dangerous, it will either be ignored or registered without any ensuing effect. If, however, the sound is perceived as dangerous, messages are sent to the limbic system - the emotional part of the brain – and the conscious part of the brain. A message then goes to the autonomic nervous system, which regulates unconscious or involuntary functions and is responsible for our flight or fight reactions. Messages will then be sent back to the limbic system and the conscious brain. The conscious brain will gradually become more aware of the uncomfortable sound, and the more aware it becomes, the more sensitive the filtering and pattern recognition box will be. The emotional reactions of the limbic system intensify, and the reactions of the autonomic nervous system become more pronounced. In this way, a spiral process may gradually be created in which the four boxes reinforce themselves and each other. Research has shown that once the spiral is set in motion, the perception of sound no longer depends upon the original source. This effect on the limbic and autonomic nervous system is also known from stress analyses, and it is therefore not surprising that stress has been shown to be one of the most exacerbating factors of tinnitus. The stress levels of the tinnitus sufferer increase as a result of the tinnitus, which, in turn, leads to increased perception of the tinnitus.

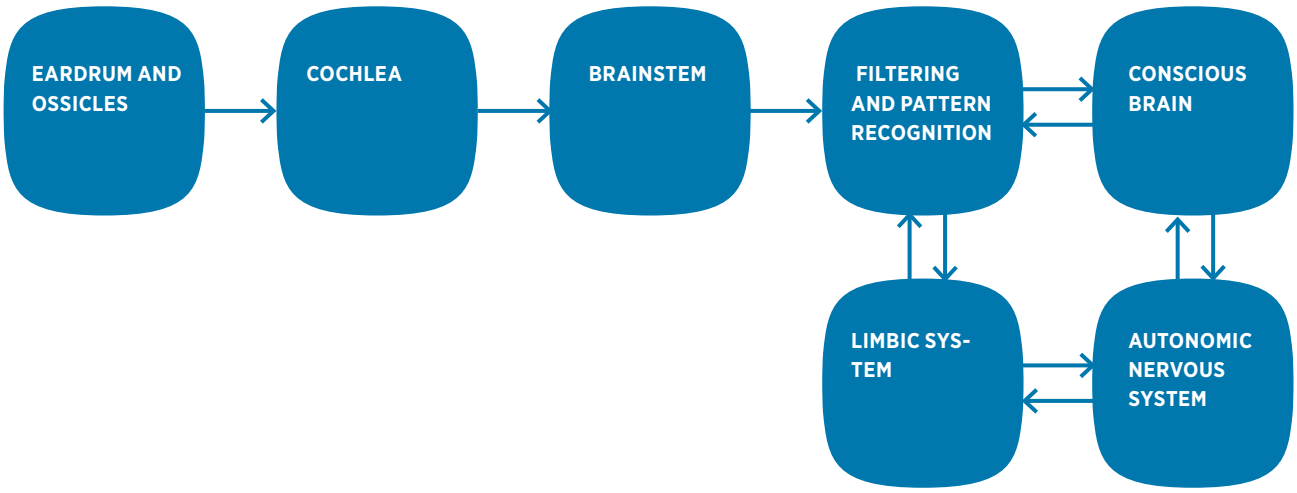

Fig 1: Example of a neurophysiological model that includes the central part of the auditory system. A spiral may gradually be created in which the last four boxes reinforce themselves and each other (McFerran et al, 2007)

Tinnitus treatment

The large variety of proposed causes of tinnitus generates a correspondingly large variety of suggested treatment methods. These methods can generally be categorized into two groups: those that attempt to treat tinnitus directly, and those that aim to treat tinnitus by focusing on the patient's reaction to tinnitus. The treatment methods associated with the first approach attempt to reduce the perceived degree of tinnitus or eliminate it altogether, for example through the use of various kinds of medicine (Dobie, 1999; Murai et al., 1992), surgery or electrical suppression (Rubinstein et al, 2003; Dauman 2000; Dobie et al., 1986). However, despite the fact that interesting findings have been obtained, a clinically applicable form still remains to be found. At present, therefore, the second approach, in which the focus is on the patient's reaction to tinnitus, is considered to be the primary treatment approach. The large variety of proposed methods of treatment makes it impossible to set a definite standard for tinnitus treatment. However, a review of some of the most prevalent tinnitus therapies and research in this area may lead to the identification of the elements that are most important in effective tinnitus management.

Masking therapy (Hazell, 1987):
One widely-used method of treatment is masking therapy. This method uses a masker to mask the tinnitus, so that the tinnitus is no longer audible to the patient. The masker generates a mild low-level type of broadband noise which is less disturbing than the tinnitus sound and therefore easier to get used to and ignore. The treatment does not cure tinnitus. When the masker is removed, the tinnitus is often unchanged, but the treatment provides immediate relief and gives the patient a feeling of control. This method puts much emphasis on counselling. The clinician gives the patients various kinds of information, talks to them about their problems, provides assurance, and works with attention, relaxation and the use of diaries.

Habituation therapy (Hallam, 1989):
Another prominent method is habituation therapy. This method exploits the plasticity of the brain and its ability to get used to various different stimuli. The method focuses on blocking the tinnitus signal to prevent it from activating the limbic and autonomic nervous system. In this way, the tinnitus sound will not trigger any reaction even if it is perceived, and the patient will not be troubled by it. In other words, the sound becomes easy to ignore - like the sound of a refrigerator. An attempt is also made to block the sound at the unconscious level, so that the patient is not even aware of the sound. This is done by counselling and/or training the patients in the processes related to their problem and therapeutic processes. Elements of the training include relaxation, attention control, distraction and modification of the environment. Paradoxically, the patient has to focus on the tinnitus sound to learn to get used to it, and it is therefore important that the sound is not masked.

Retraining therapy (Jastreboff, 1990):
Retraining therapy is a kind of habituation therapy. This method divides the treatment into two areas – counselling and sound therapy. The counselling used in this therapy takes a direct form in which it is explained to patients how tinnitus arises, how the problems they experience are mainly due to the activation of the limbic and autonomic nervous system, and how it is possible to make the brain reduce these undesirable reactions. The patient is also told how the brain can learn to ignore the tinnitus sound at a conscious or unconscious level (Jastreboff, 2000). The sound therapy element involves stimulating the ear with sound to reduce its tendency to become hypersensitive in the absence of sound. The stimulus consists of a constant low-level broadband noise. The noise must not mask the tinnitus signal, as this would prevent the brain from becoming used to and subsequently learning to suppress the tinnitus sound. Partial masking cannot be used either, as this would contribute to distorting the tinnitus signal, which would also prevent the brain from becoming used to the original tinnitus sound. According to Jastreboff (2000), the masking noise should be at the point where the noise and the tinnitus signal just start to mix (the mixing point). The tinnitus signal should be faintly perceptible, and the noise signal will then help the brain to ignore the signal.

Cognitive behavioural therapy (Henry et al., 2001, Henry et al., 2002):
Cognitive Behavioural Therapy (CBT) is a kind of psychological treatment method that aims at identifying and modifying undesirable behaviour and thoughts by using behavioural change and cognitive restructuring. The focus is on providing behavioural and cognitive techniques that are applicable in real life, and on trying out coping strategies in difficult situations. CBT not only involves thinking differently, but also changing habits and finding ways to cope with difficult situations. The aim is to reach the point at which patients can accept their tinnitus and feel able to ignore it. The tinnitus sound is still there; it is the way in which the patient thinks about the tinnitus that results in specific reactions. CBT includes providing information about tinnitus, self-help strategies, sleep, depression, attention control, relaxation, coping strategies and the prevention of relapse.

Neuromonics tinnitus treatment (Davis, 1995, 2002a, 2002b, Hanley et al., 2008):
The final treatment we will discuss here is Neuromonics Tinnitus Treatment (NTT). NTT is a clinical treatment method that integrates principles from many different tinnitus therapies. The treatment comprises two elements: music and counselling. Music stimulates the auditory pathways across all frequencies and is spectrally modified in accordance with each patient's hearing profile. The approach takes into account the effect of the individual hearing loss on the perception of music, as well as the individual patient's tinnitus profile. The aim is to create a stimulus that can interact with the individual patient's tinnitus at the lowest possible level of loudness. The music is played to provoke an intermittent interaction with or masking of the patient's tinnitus, in order to enable the patient to obtain a pause from the signal, relax and feel in control. The level of the music is subsequently adjusted to obtain intermittent interaction with the tinnitus signal – the peaks of the music mask the tinnitus, while the troughs permit the tinnitus to be briefly heard. Afterwards, the music is adjusted again, and in this way, the audible tinnitus signal is gradually increased. The idea behind the incremental increase of the signal under relaxed conditions is to gradually densensitize the patients to the tinnitus signal (Davis et al., 2002a, 2002b).

Common elements of effective tinnitus management

A review of the most widely-applied tinnitus treatment methods, together with other suggested treatments and research conducted in the area, reveals that four elements recur in effective tinnitus management.

Counselling:
First of all, education and counselling seem to be important factors in every type of tinnitus management. Providing different kinds of information helps the patients to understand their problems and feel less vulnerable and to participate in the treatment. Patients are typically provided with general information about hearing, hearing loss, tinnitus epidemiology and the tinnitus mechanism, including neurophysiological models and explanations of the brain's capacity to learn to ignore stimuli. It is unclear which of these types is most important, and the information that the various treatment methods emphasise varies greatly. Some tinnitus therapies rely solely on the provision of information, which for many patients is sufficient to stop the negative spiral that can easily be built up around the fear of tinnitus.

Sound stimulation:
Secondly, most methods incorporate the use of sound in some manner to reduce the negative effects of tinnitus. As discussed above, some of these methods involve specific protocols and certain restrictions for using sound to manage tinnitus. Others take individual preferences and circumstances into account and use sound in a less stringent manner (Henry et al., 2008). However, a pivotal point in all of these methods seems to be the maintenance of a background of constant low-level sound to reduce the contrast between tinnitus and the acoustic environment. By reducing the contrast, an environment is created in which it is easier for the tinnitus to go unnoticed.

Stress reduction:
Thirdly, stress reduction is used to great effect in several tinnitus management methods. Perhaps the most exacerbating factor for tinnitus is stress. As previously discussed, tinnitus affects the brain in more than one way. It triggers the auditory centre, and it also affects the emotional control centre, causing stress hormones to be released. As a result, the tinnitus sufferer becomes more stressed because of the tinnitus, which in turn increases the perception of the tinnitus. Almost anything that reduces the patient's level of stress or anxiety will therefore decrease the severity of the tinnitus. Various approaches are used, such as biofeedback, hypnosis, yoga, meditation or massage. It is well documented in the literature that music has the ability to reduce stress and make people feel more relaxed, comfortable and less anxious (Hanser, 1985, Burns et al., 1999, Scheufele, 2000). Calming sounds are therefore often used, either in combination or alone, to induce a sense of relief from the stress or tension caused by the tinnitus.

Hearing aids:
A fourth element in effective tinnitus management is the use of hearing aids. Several studies have shown how amplification in itself can be very effective in the treatment of tinnitus (Surr et al., 1985; Kochkin et al., 2008; Searchfield, 2005; Searchfield et al., 2010; Bo et al., 2007). The exact mechanisms underlying the beneficial effects of amplification are uncertain, but it may be that tinnitus is exacerbated by silence, as the brain then seeks out the neural stimulation it is being deprived of by the hearing loss. Amplification increases neural activity and may thus assist in "turning down" the brain's sensitivity control. Another apparent factor is that hearing aids amplify background noise sufficiently to partially mask the tinnitus, or at least reduce its contrast to silence (Sweetow et al., 2010a).

The Widex Zen program

The fact that 70-85% of the hearing-impaired population suffers from tinnitus makes it highly relevant for

a hearing aid manufacturing company to look beyond just addressing the hearing impairment through the amplification of sound, and to try to address the tinnitus issue as well. Bearing in mind the four essential elements of effective tinnitus management, Widex took up the challenge of providing a hearing aid that would not only offer amplified sound of the highest quality across a broad frequency range, but also offer sound stimulation to reduce the contrast between the tinnitus and the acoustic sound environment, and help the tinnitus sufferer relax. The result is the Widex Zen program, which is a harmonic sound program that is capable of producing soothing tones and chimes and broadband noise. The program can be used to provide sound stimulation in various forms of tinnitus therapy, as well as in less formal settings, where tinnitus sufferers simply activate the program whenever they feel that it is needed and helpful. The soothing tones and chimes of the Widex Zen program are based on fractal technology. Using fractal technology, tones are created that follow the known rules of music without ever repeating themselves. The music progresses in a smooth, rather predictable manner, which promotes passive listening. The tones are created in accordance with what is known about music's relaxing properties. Music is in itself a very complex concept, and it is practically impossible to isolate the individual components of music without compromising musicality. It is therefore difficult to specify exactly which aspects of music are required to obtain relaxation, and consequently, which kind of music is likely to have an effect. However, some general "rules" apply. Slow music tends to soothe, fast music tends to stimulate; lower pitches tend to calm, higher pitches tend to excite, and loud music and music with sudden changes in rhythm or loudness tend to be alerting, whereas slow music that does not vary much in overall rhythm or loudness tends to be relaxing (Hevner, 1933, Hevner, 1936, Bella et al., 2001). Another factor to keep in mind is that the individual's perception of music is affected by extra-musical factors such as familiarity with the music, musical preferences, previous experience with music, and personality (Hann et al, 2008). All of these factors suggest that it is unrealistic to expect a specific piece of music to affect all individuals in the same way, or that the relaxing effect will always be produced by the same piece of music. To accommodate individual preferences, the Widex Zen program offers six different "Zen styles". Five of these consist of soothing tones and chimes and can be further individualized by adjusting the tempo and pitch of the piece. The sixth Zen style consists of a broadband noise that can be used either individually or in combination with the other Zen styles. It is also possible to adjust the volume of the Zen styles, either via the fitting software or by using the volume control on the hearing aid. For further relaxation possibilities, the Zen program includes a setting in which the microphone sound is deactivated and only the Zen style is played. When fitting the Zen program, it is possible to include up to three different Zen styles between which the user can toggle. To make sure that the Zen styles are audible at all times, the Zen program takes individual hearing loss and background noise into account when generating the fractal tones and chimes and the broadband noise.

Several studies have been conducted to investigate whether the Zen program is useful in clinical settings. These studies show very promising results. The majority of the participants found the Zen tones to be relaxing. They preferred the Zen tones to hearing aid amplification alone or broadband noise, and reported a reduction in the perceived degree of tinnitus as a result of using the Zen program. (Kuk et al., 2008; Kuk et al., 2010; Sweetow et al., 2010b).

As mentioned earlier, education and counselling are very important factors in every type of tinnitus management. The "Widex Tinnitus Guidelines" are therefore available to support the hearing care professional in counselling the patient.

Conclusion

Tinnitus is a much disputed subject. Many different causes have been suggested, but no consensus has yet been reached. The large variety of suggested causes of tinnitus generates a correspondingly large variety of proposed methods of treatment. By examining the most widespread therapies, the general literature on tinnitus, and the research performed in this area, it is possible to identify the most common elements in effective tinnitus management. On the basis of these elements, Widex provides a hearing aid program that can be helpful to tinnitus sufferers, as clinical studies have confirmed.

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