ReSound Tinnitus Management: ReSound TSG and Tinnitus Management

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Tinnitus is a concern for many people, and affects aound 10% of the overall population, with approximately 3-5% of the population suffering from clinically treatable tinnitus (McFadden, 1982). As hearing loss is increasingly identified and diagnosed, this trend is most likely to continue and grow (Vernon, 1998). Clinicians and people affected by tinnitus have struggled finding flexible tinnitus treatment devices that are suitable components of a tinnitus treatment and counseling support program. ReSound offers an advanced combination unit of hearing aid and Tinnitus Sound Generator (TSG), that provides fitting flexibility for clinicians, and an innovative TSG solution for. It can be used as a combination unit to address both hearing loss and tinnitus.

WHAT IS TINNITUS, AND WHAT CAUSES IT?

Tinnitus is an involuntary perception of sound that originates in the head (McFadden, 1982). It is most commonly referred to as 'ringing in the brain', but can take on a number of perceptual characteristics, such as clicking, chirping or pulsing. It can be constant and steady, or it can be intermittent. The perception of tinnitus can greatly vary from person to person.

Outside of known medical complications that may lead to tinnitus, it is important to note that the exact mechanism of tinnitus causation is not exactly known, but there are different theories and models that have been examined. It is also important to remember that psychological factors play a large role in tinnitus perception. One of the more studied, and well-accepted, neurophysiological models of tinnitus discusses the role of cochlear damage in regards to tinnitus causation (it is a very in-depth model, and this paper will only address some of the main points). It is believed that when the outer hair cells (OHC) are damaged, they are no longer able to carry out an important role, which is to inhibit the neuronal firings of the inner hair cells (IHC) in the absence of auditory input. When the OHC are no longer able to perform this function, the IHC spontaneously fire neurons to the brain, which are processed, amplified and recognized as noise, even in the absence of auditory input. This noise is recognized as tinnitus (Figure 1).

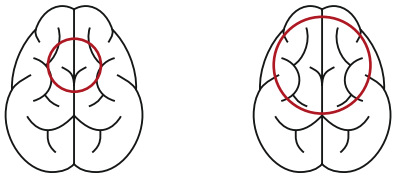

Figure 1. Abnormal tinnitus perception due to outer hair cell damage.

Tinnitus does not seem to be limited to OHC damage alone, as it seems IHC damage can also play a role in the generation of tinnitus. This suggests that there are additional mechanisms that are also responsible in tinnitus generation beyond OHC damage (Jastreboff & Hazell, 1993). There are other theories as to the mechanisms that may be causing tinnitus, but it is not the intention of this paper to discuss all of them.

The strength of a person's tinnitus is not only due to cochlear damage, but to the focus that one puts on the tinnitus. This is called 'prioritization'. The more focus, or priority, a person puts on the their tinnitus, the more audible it will be, and the more easily the brain will be able to detect the neuronal patterns that characterize the tinnitus, even in the presence of other auditory input, such as background noise or speech. For most people, they can ignore and habituate to the tinnitus quite easily, and the tinnitus blends into the background without much further notice. But, for some individuals, this is not the case.

When the tinnitus becomes a focal point, it can lead to negative emotions that are associated with the tinnitus, such as frustration, anxiety and helplessness. These negative emotions, which involve the limbic system, can lead to physical changes and reactions in the body, such as stress, which includes the autonomic nervous system (Henry et al, 2002). When a person is stressed by the situation, the

tinnitus remains, or at times can get worse, which prompts the cycle to repeat itself. This is often referred to as the 'Vicious Cycle of Tinnitus' (Figure 2). Apart from tinnitus that is caused by a known medical complication, most key opinion leaders and clinicians agree the goal of tinnitus treatment is to break the vicious cycle, and have a person in control of their reactions to the tinnitus, ultimately learning to habituate to their tinnitus. Habituation is the process in which one becomes 'used to' the stimulus. A good example of this is air conditioner noise. Usually, people will hear the air condition noise when they walk into a room, since the air conditioning stimulus is new to the brain, but quickly learn to put the noise in the back of their mind, and focus on more important stimuli. When the air conditioning noise is no longer recognized by the individual, habituation to it has occurred.

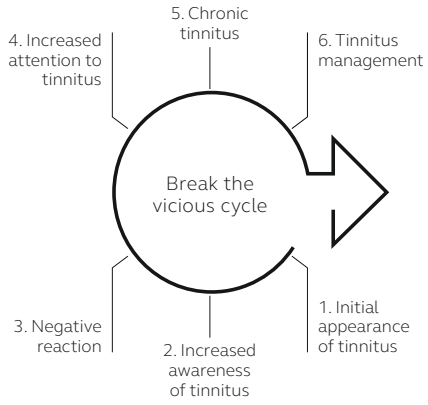

Figure 2. The vicious cycle of tinnitus

By breaking the vicious cycle, we still enable the individual to attend to their tinnitus, but rather than react negatively to it, they are aware and accept the tinnitus. This can result in more control over the tinnitus. Ultimately, the goal over time is to habituate to the tinnitus altogether, although complete habituation may not occur in many individuals.

TINNITUS TREATMENTS AND COUNSELING METHODS

There are many different types of tinnitus treatments, resulting in a number of methods to choose from. We will discuss some of the more common treatments, one of which is sound therapy, also known as acoustic therapy. Sound therapy is simply the introduction of an external sound, to help reduce the contrast of the tinnitus against the background. By increasing the level of external sounds in the client's environment, we aim to decrease the perception of the tinnitus. A common example to illustrate sound therapy is the "candle in the dark" analogy. A candle lit in a dark room becomes the focal point, as it is very easy to detect the light against the dark background. In contrast, the same candle in a lit room becomes less noticeable against the background (Figure 3).

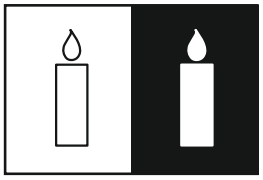

Figure 3. Sound therapy analogy - the strength of the candle flame intensity is less noticeable in a well-lit room , as opposed to being in a dark room.

There are many tools that can be used in sound therapy. ReSound ReSound offers a combination unit, which has both hearing aid features, as well as tinntus sound generator (TSG) features to help address tinnitus. The TSG can be used in sound therapy to help increase the level of background noise, which can help decrease the contrast of the tinnitus. The ReSound TSG combination also contains other unique features, such as frequency shaping of the white noise, amplitude modulation and environmental steering, which can help personalize the TSG and provide more comfort for the individual. In addition, with the introduction of open fit hearing instruments, we are able to allow more natural sound through the ear canal. For some individuals, simply providing amplification through the open fit hearing instrument is enough sound therapy to help them habituate to their tinnitus, even without the TSG.

Other tools that can be used are sound pillows, which generate noise and can be useful for people who have difficulty sleeping. More common everyday sounds, such as TVs, radios, fans, or even opening a window to hear environmental sounds from outside can also be useful. In addition, tinnitus apps, such as ReSound Relief and music can be very helpful forms of sound therapy. In its simplest form, sound therapy is the introduction of an external sound to help 'drown out' the tinnitus, and allow the individual to habituate to their tinnitus.

Another well-known and heavily practiced tinnitus treatment approach is tinnitus retraining therapy (TRT). TRT has a well-defined protocol, where emphasis is placed on educating the client on the neurophysiologic foundations of tinnitus. TRT aims to provide the client with a better understanding of where tinnitus comes from, as well as understanding the reactions produced by the limbic system and autonomic nervous system in response to the tinnitus. The goal is, through knowledge and understanding, for the client to have more control over their emotions and reactions to the tinnitus, allowing them to more efficiently cope, and ultimately habituate to their tinnitus (Henry et al, 2002). Sound therapy is vital component of TRT.

There are also other treatment plans including different psychological and psychiatric models for more severe cases of tinnitus, that have also proven effective. It is not the intention of this paper to explore these models, but information can be found explaining these methods in greater detail. Many times, a combined approach to tinnitus treatment, involving multiple disciplines and treatments can occur according to the individual's needs. Regardless of what treatment plan is used, the goal is to have a person in control of their tinnitus and how they react to it, as this will help break the vicious cycle (Figure 4) and allow for habituation.

Break the vicious cycle

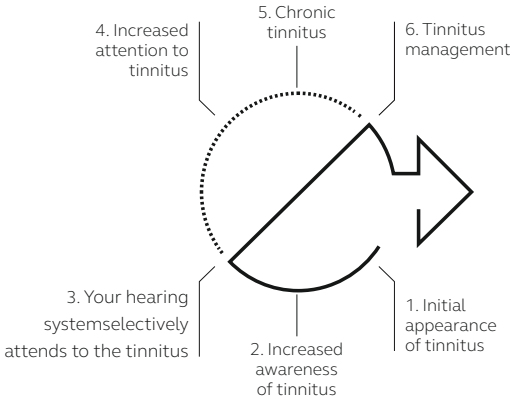

Figure 4: Breaking the vicious cycle - to help someone take control of their tinnitus, we must first help to reduce the attention to the tinnitus, by changing the way they perceive their tinnitus.

Regardless of what method you choose to use, monitoring the status of any treatment plan is very important. It is suggested that both subjective and objective measurements are taken through treatment. Objective measures are often carried out by common tinnitus questionnaires, such as the Tinnitus Handicap Inventory (THI), Tinnitus Handicap Questionnaire (THQ), Tinnitus Functional Index (TFI) or Tinnitus Reaction Questionnaire (TRQ). Questionnaires try to look at varying aspects of the tinnitus and how it is affecting the person. Questionnaires can be given as baseline measures, and again later on in treatment for post-treatment measures. Subjective measures are typically in the form of client feedback. Letting the person with tinnitus discuss how the treatment works for him / her and how it affects his / her tinnitus can lead to important insights on the part of the clinician as well as the individual. Both measures are important to fully understand the effects a tinnitus treatment plan has on the individual . It is important to note that post-treatment measures should be considered carefully, as early results can be due more to the placebo effect rather than the treatment itself. Lastly, creating realistic expectations from the start is often helpful. As full habituation may not take place for all, and tinnitus treatment can take an extended period of time (6 mos - 2 yrs. or longer for some), it is important that one's expectations are in line with the treatment objective.

RESOUND TSG COMBINATION UNIT

The ReSound TSG combination unit is a fully functional and flexible hearing loss and tinnitus solution to assist in your treatment of tinnitus. For your clients, it offers a cosmetic and customizable solution to help treat their tinnitus, helping to provide more relief and a better quality of life. The hearing instrument in the TSG combination unit offers all the advanced digital technology of our ReSound hearing aids, but also unique TSG features such as frequency shaping of the white noise signal, amplitude modulation and Environmental Steering.

Most literature suggests that using a broadband stimulus activates the most neurons, and is most effective for sound therapy. Based on this knowledge, the default noise setting for the ReSound comibaton unit is set to a broadband filtering setting, but has the flexibility of low and high cut controls to provide more individualized comfort.

Another feature, which can be personalized for comfort, is amplitude modulation (AM). AM is a fluctuation in the level of the noise signal while all other spectral components remain uniform. AM attenuation in in the ReSound TSG combination units is non-deterministic (randomized) to avoid audible periodicity, meaning that the amount of attenuation will not always be the same. AM in the ReSound fitting software, can be configured to a maximum attenuation of 3 options:

- Mild (-6 dB)
- Moderate (-10 dB)
- Strong (-14 dB)

This means that if a 'Moderate' AM setting is chosen, the white noise energy can fluctuate up to -10dB from the programmed volume of the tinnitus sound generator (TSG). For example, if the programmed volume of the TSG is 65dBSPL, and a 'Moderate' AM setting is chosen, the TSG volume can fluctuate between 65dBSPL and 55dBSPL, keeping in mind that the fluctuations will be randomized. Once the AM is activated, you have the option of controlling the speed at which the AM fluctuations occur. You can select between three options:

- Slow (2 secs)
- Medium (4 secs)
- Fast (8 secs)

The time represents how often a fluctuation will occur in the white noise energy. Amplitude modulation and amplitude modulation speed are strictly comfort features, and should be considered on a case-by-case basis.

A truly unique feature to the ReSound TSG combination unit, that can be beneficial in tinnitus treatment, is Environmental Steering. Environmental Steering acts as an automatic volume control that adjusts the level of the white noise signal, according to the listening environment. It uses a classifier that assigns the input into one of seven listening environments (Quiet, Soft Speech, Loud Speech, Soft Speech in Noise, Loud Speech in Noise, Moderate Noise and Loud Noise).

Since typically people report their tinnitus being worse in quiet situations, when the user is in a 'Quiet' environment, the TSG volume will be at the programmed setting. When the user is in a more speech-heavy environment, or a noisy environment, less noise is needed to decrease the contrast of the tinnitus, since there is more environmental stimuli present, and thus the TSG volume will decrease (Figure 5).

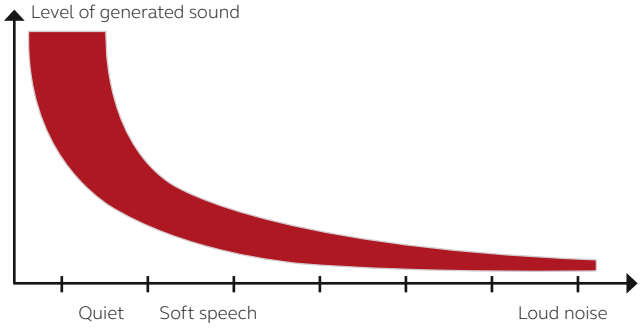

Figure 5. Environmental Steering - The tinnitus sound generator volume will automatically adjust according to listening environment.

Environmental Steering serves a number of purposes. First, for users who are not familiar with a manual volume control, or do not fully understand the aim of sound therapy (or tinnitus treatment), Environmental Steering can help avoid the potential risk of completely masking the tinnitus. Completely masking the tinnitus does not allow for habituation, as one cannot habituate to what is not audible, and this can be detrimental in the tinnitus treatment.

Environmental Steering also ensures that the TSG signal does not interfere with important information, such as speech. Lastly, taking away the need for a manual volume control can put less emphasis on the instrument, and for some, may help reduce the attention that is paid to the tinnitus. This can occur if one is constantly adjusting the volume control. If Environmental Steering is not preferred, a manual volume control can be activated. For some tinnitus clients, this provides a greater sense of control. Environmental Steering or the manual volume control can be selected in the 'Sound Level Adjustment' drop-down option in the Aventa fitting software.

NOTE:

- Within any individual program the manual volume control can either be off, designated to the hearing instrument or designated to the TSG. It cannot be active for both the hearing instrument and TSG in the same program.
- By default, amplitude modulation and Environmental Steering are deactivated.
- Selecting 'Synchronize' in the software will binaurally synchronize the amplitude modulation, Environmental Steering and manual VC features. Synchronization is only active in a binaural fitting.

Another flexible feature in the ReSound TSG combination unit is the option of having multiple customizable programs. ReSound can be fit as a combination unit, where the hearing aid is active as well as the TSG, or the hearing aid function can be deactivated, and it can act as a tinnitus sound generator only. It can also be fit as a hearing instrument only, should you want to start tinnitus treatment using only amplification, rather than activating the TSG from the start. Having the flexibility to control how you want to program the instrument, and having four programs allows you to truly personalize the device however you feel is most appropriate for your client.

RESEARCH STUDIES USING RESOUND TS (STUDY A & B)

Study A and B were multi-facility external trials conducted at multiple well-established tinnitus clinics worldwide, to evaluate the benefit of the ReSound TSG combination unit in regards to tinnitus treatment. The studies also focused on finding mixing point information, Environmental Steering and amplitude modulation preferences, all important functions of the ReSound TSG combination unit. It is important to note that both trials used some form of counseling and treatment (e.g. TRT) in combination with using the ReSound TSG combination unit.

Trial design for Study A:
This study involved 30 people with tinnitus, falling within Jastreboff's tinnitus category 1 and 2 (Henry et al. 2002). The subjects presented mild and moderate tinnitus for at least 6 months. People affected by the Menière's disease and middle or external ear disease were excluded.

After fitting the ReSound TSG combination unit, Tinnitus Retraining Therapy (TRT) was administered for 6 months, and the effect of the treatment was evaluated using the Structured Interview (Jastreboff & Jastreboff 2000), TRI Tinnitus Patient Assessment and Outcome Measurement (Langguth et. al 2007), and THI self-administered questionnaire (Newmann et al. 1996).

Trial design for Study B:
24 subjects with varying perceptions of tinnitus were recruited for this trial. 13 of the test subjects had varying degrees of sensorineural hearing loss with thresholds falling within the mild to moderate range, and eleven of them had no significant hearing loss. The subjects were fit with with the ReSound TSG combination unit. 22 subjects were fit binaurally and two subjects were fit monaurally. They were seen over a period of approximately six months for five visits. The Tinnitus Handicap Inventory (THI) and Tinnitus Handicap Questionnaire (THQ) were administered at the initial, mid and final visits to evaluate how the subjects perceived their tinnitus following the fitting. Half the test subjects were fitted with the Environmental Steering enabled at the first visit, and the other half with the volume control enabled. Approximately four weeks after visit one, the sound level adjustment (i.e. Environmental Steering and manual VC) was switched to the opposite of what they were initially fitted with. The test subjects then rated their preferences on a take-home questionnaire. Amplitude modulation was evaluated by initially giving all subjects 2 programs - with modulation and one without. Approximately 2 weeks after the first visit, all subjects were asked how they perceived the modulation and then chose one TSG program, either with or without modulation. This TSG program was adjusted based on their preferences.

Results for Trial A:
Assessment results were collected at the initial fitting, and again after 3 and 6 months. Figure 6 shows the development in the 6 months' time frame of THI scores, and Figure 7 shows the structured Interview VAS scores regarding 'annoyance', 'intensity' and 'tinnitus effects on clients' life'. After 6 months all differences are significant (THI: p=0.001; annoyance and intensity: p<0.001; life effect: p=0.002), (Carraba et. al 2008).

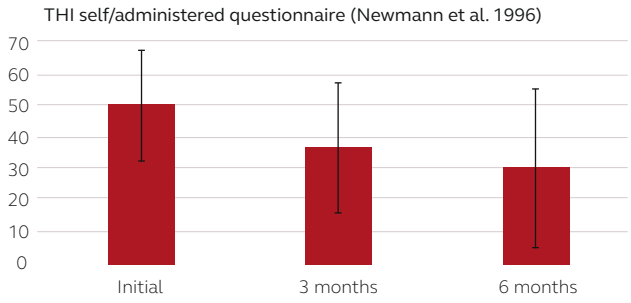

Figure 6. Pre- and post THI questionnaire results

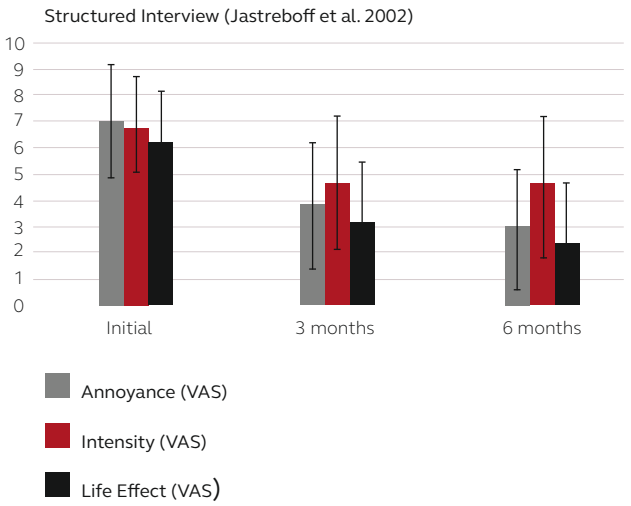

Figure 7. Pre- and post Structured Interview results.

Results for Trial B:
20 of the 24 subjects answered the TRQ and 16 answered the THI. The subjects revealed a significant improvement in their tinnitus questionnaire scores over a period of six months, which was documented by an improvement in their THI and TRQ scores. On an average, the THI scores dropped significantly from 58.4 at the start to 29.9 at the end of six months (P<0.05) and the TRQ scores dropped significantly from 50.8 at the beginning of the trial to 33.0 at the end of six months (P<0.05) as shown in Figure 8.

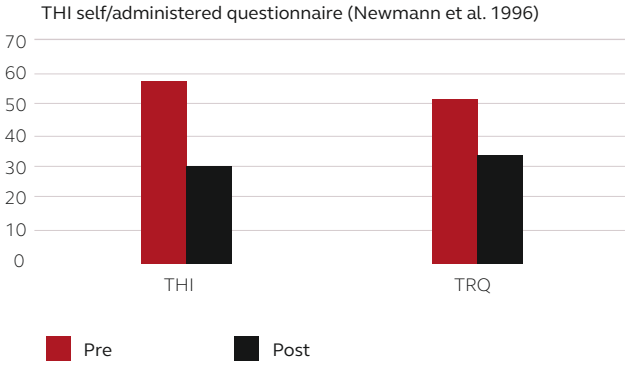

Figure 8. Pre- and post THI and TRQ results.

As far as the features of the TSG, 68% of the subjects preferred the volume control over Environmental Steering. and 73% preferred continuous noise over modulated noise. Approximately 82% of the subjects preferred the filter settings to allow broadband noise, while 18% preferred more narrow-band filter settings.

In conclusion, the trials revealed ReSound TSG to provide significant benefit in improving the client's perception of their tinnitus. The various feature options make ReSound TSG a very flexible tinnitus solution, allowing the professional to personalize the fit according to client preference.

Other notable conclusions:

- No subjects wearing the TSG reported a worsening in tinnitus (or hearing) at the conclusion of the 6 month trial.
- The average pitch match for all subjects was 9kHz.
- 22 subjects fit binaurally; 2 subjects fit monaurally.
- Initial broadband frequency filter settings were maintained for 15/22 subjects.
- The sound quality of the hearing aid received an average rating of 8.28 out of a possible 10 (1 = poor sound quality, 10 = excellent)

CONCLUSION

Individual differences and user comfort should always be considered on a case-by-case basis with regards to tinnitus, as tinnitus can vary greatly between each individual. Please review the most current ReSound Fitting Software guide, for more detailed instruction on how to fit the device in the ReSound Fitting Software.

In conclusion, ReSound offers a unique state-of-the-art hearing aid and tinnitus combination unit, that will provide you with the flexibility to address your client's needs, for both hearing loss and tinnitus treatment.

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