Tinntrain: A multifactorial treatment for tinnitus using binaural beats

By J. Ben David, A. Naftali, and A. Katz

Tinnitus manifests itself in many ways. In addition to the annoyance it causes, it may also result in anxiety, stress, depression, fatigue, and a general state of poor health. The psychological symptoms may well start prior to the onset of tinnitus. Therefore, a multidisciplinary approach to the problem is appropriate.

Tinntrain is a highly individualized, multi-factorial treatment concept for tinnitus administered by a specially trained team. It includes a portable mp3 player that the patient can carry anywhere and can use at home or in bed if the patient suffers from insomnia associated with tinnitus.

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One of the most important elements of the *Tinntrain* relaxation methodology is the Brain Wave Entrainment (BWE) technique. BWE is based on the principle of stimulation frequencies and binaural beats. The human brain has a tendency to replace its dominant electrical response frequency and mimic or copy the frequency of an external stimulus, encouraging brainwave adjustment, balance and relaxation. Using the principle of "frequency following response," the brain reproduces the frequency it receives via auditory or visual stimulation, leading to the desired change, i.e., relaxation, by reducing the excessive beta wave frequencies, which may exacerbate the reaction to tinnitus, and substituting alpha waves, which promote calmness and tranquility.

HOW BINAURAL BEATS ARISE

Binaural beats or binaural tones are auditory processing artifacts, or apparent sounds, the perception of which arises in the brain in response to specific physical stimuli. This effect was discovered in 1839 by Dove and explained by Oster.[1] The perception is a low-frequency beating or pulsation in loudness and sound localization when two tones are presented separately at slightly different frequencies at each ear through stereo headphones. The frequency of the tones must be below approximately 1000 to 1500 Hz for the beating to be heard. The difference between the two frequencies must be small (below about 30 Hz); otherwise, the two tones will be heard separately and no beat will be perceived.

For sound localization, the human auditory system analyzes interaural time differences at small frequency ranges, called critical bands. For frequencies below 1000 to 1500 Hz, interaural time differences are evaluated from phase differences and the perceived sound will depend on the frequency difference between both ear signals.[2] For frequency differences between the ear signals of above 30 Hz, the "cocktail party effect" begins to work, and the auditory system perceives the presented ear signals as two different sounds at two different locations. The sensation of binaural beats is believed to originate in the superior olivary nucleus. Binaural beats appear to be related to the brain's ability to locate the sources of sounds in three dimensions and to track moving sounds, which also involves inferior colliculus neurons.[3]

Binaural beats reportedly influence the brain in more subtle ways through the entrainment of brainwaves,[4] and can be used to reduce anxiety[5] and provide other health benefits, such as stress management and pain control.[6]

This phenomenon is called *"frequency following response."* The concept is that if one receives a stimulus with a frequency in the range of brain waves, the predominant brain wave frequency moves toward the frequency of the stimulus (entrainment[7]). The stimulus does not have to be aural; it can be visual or a combination of aural and visual.[8,9]

The frequencies of human brain waves are below about 40 Hz. Perceived human hearing, however, is limited to frequencies from about 20 to 20,000 Hz, though infrasound—sound below 20 Hz—has observable effects on humans. Since these low-frequency sounds are not audible, particularly at low volume levels, binaural beat frequencies are used to account for this lack of perception. Beat frequencies of 40 Hz have been produced in the brain with binaural sound and measured experimentally.[10]

BRAIN WAVE ENTRAINMENT

Beta waves have a frequency in the range of 14 to 30 Hz and are predominant in our normal and waking consciousness. Alpha waves, which have a frequency in

the range of 7 to 13 Hz, are associated with a relaxed state. Daydreaming and a light form of meditation are known to occur in the alpha state. Theta waves have a frequency of 4 to 8 Hz and are predominant in states of deep relaxation and meditation. Delta waves are the slowest of the brainwaves, with a frequency ranging from 1 to 3 Hz. They are predominant in periods of deep sleep and unconsciousness.

Since the frequency of brain waves usually varies according to the state of the listener, the brain wave entrainment theory proposes the use of certain beats and sounds in certain frequencies—usually embedded in music that the brain follows, hence leading the brain into the desired state. This explains why some types of music have certain effects on the brain.

It should be noted that brain wave entrainment does not use only music. In fact, some use what are called raw "binaural beats," which are embedded in white noise or in sounds of nature or in combination with music. When the perceived beat frequency corresponds to the delta, theta, alpha, or beta range of brainwave frequencies, the brainwaves entrain to or move toward the beat frequency.[11] For example, if a 315-Hz sine wave is played into the right ear and a 325-Hz wave into the left ear, the brain is entrained towards the beat frequency 10 Hz, in the alpha range. Since alpha range is associated with relaxation, this has a relaxing effect. If entrainment moves into the beta range, enhanced alertness will occur.

Experimentation with binaural sound stimulation using beat frequencies in the beta range with some participants and the delta/theta range with other participants found better vigilance performance and mood in those on the awake alert state of beta range stimulation.[12] These incorporated frequencies are components of the Tinntrain device, and they facilitate the desired conditioning reflex in order to enable the patient to cope with debilitating tinnitus.

In addition to brain wave entrainment, the Tinntrain protocol incorporates a number of other processes, including cognitive-behavioral therapy (CBT). This therapy evolved out of the cognitive theory of emotions, which asserts that a patient's experience of a situation or event depends on the way he perceives the event and not on the event itself. A number of authors have reported beneficial results using CBT with tinnitus patients.[13-15] Other relaxation approaches incorporated into CBT include progressive muscle relaxation, autogenic relaxation, attention focusing, guided imagery, and techniques for minimizing intrusive thoughts.

TINNTRAIN APPROACH STUDIED

The authors recently conducted a study to determine the effects of the multifactorial, multidisciplinary *Tinntrain* approach on tinnitus patients.

Subjects

Twenty-six patients suffering from subjective tinnitus took part. Eighteen had bilateral tinnitus and 8 had unilateral tinnitus. The mean age was 48 and the mean duration of tinnitus before treatment was 4.5 years.

Etiologies included ototoxicity, otosclerosis, Meniere's disease, sudden hearing loss, acoustic trauma, head trauma, and noise-induced hearing loss; slightly fewer than half were idiopathic.

Methodology

An initial pool of subjects suffering from intractable tinnitus underwent a series of diagnostic procedures from an ENT or neuro-otological consultant. They were then referred to the Mount Carmel Relax Clinic for psychological evaluation. There, two questionnaires were administered to them: the Tinnitus Handicap Inventory (THI) and a stress-related symptoms questionnaire to determine the subjective severity of the tinnitus. Subjects were also given a detailed anemnetic questionnaire, a physical examination, tonal audiometry, and, in selected cases, ABR or MRI.

Each patient completed a questionnaire that required a detailed description of the disturbance caused by tinnitus. The tinnitus was rated on a scale of 1 (no tinnitus) to 7 (very severe tinnitus that prevents normal daily activities and causes severe insomnia and/or spontaneous awakening). The questionnaire was given pre- and post-therapy.

The somatic reaction to the tinnitus was monitored with galvanic skin response sensors based on electrodermal activity (Galvanic Skin Response-GSR) and evaluated by a biofeedback technique using a combination of aural and visual stimulation. A subject's psychophysiological profile was determined from the results of the questionnaire and somatic evaluation.

Subjects who were deemed appropriate for the *Tinntrain* approach were invited to the clinic for two or more sessions for evaluation of relaxation reaction to brainwave entrainment induced by the binaural beats technique. Following this evaluation, an individualized program of brain wave stimulation sounds and binaural beats was developed. Using the GSR monitoring results, a personalized formula of tonal stimulation was tailored to each subject to produce the binaural beats.

The main auditory wave (carrier wave) frequency was modified to the patient's preference. Generally it was between 50 and 100 Hz. The carrier wave was transformed into a binaural sound, with a frequency difference of 10 Hz. The carrier wave was modulated by the personal formula prepared using the GSR monitoring.

Subjects then selected the style of the guided imagery presented by either a male or female voice, which was presented along with the binaural beats for extra relaxation. All the above parameters were blended to produce the desired audio session to be integrated in the *Tinntrain* device.

Next, each subject chose background nature sounds and background music from a selection of music and themes especially composed for the clinic. Masking was achieved by exposure to pleasant external noises that neutralize the effect of the tinnitus. The various sounds used were generally associated with nature and were pleasant to the ear; they were composed mostly of white noise, such as the sound of rain. It was important to ensure that the masking sounds were heard in such a way that the tinnitus was only partially masked, thereby facilitating more efficient adaptation to it by habituation in accordance with the principle of Tinnitus Retraining Therapy (TRT).

It was recommended that this be carried out as much as possible using stereo headphones to facilitate the binaural beats.

During the last session, the parameters of the subject's tinnitus, including the customizing of the acoustic signal, were selected. These were then incorporated into the personalized *Tinntrain* device, which was given to the subject 3 weeks later. Each device was programmed with the subject's choice of maskers, which were blended with the specially prepared sound programs (based on the results of the brain wave sessions), plus the special recorded sessions of relaxation matched to the subject's needs, and cognitive behavior therapy explanations and guidance.

Subjects were instructed on how to use the program at home (for up to 6 hours a day for the next 3 months). During this period, they were invited to attend four cognitive behavior therapy workshops with fellow tinnitus sufferers. Only 10 of the 26 subjects chose to take part in the sessions. At the end of the 3-month period, the subjects returned for a follow-up session for re-evaluation.

RESULTS

Following the 3-month period, re-evaluation found a reduction in the degree of tinnitus disturbance in all 26 patients (See Figure 1). Figure 2 shows the number of patients as a function of disturbance degree. The mean disturbance rating was reduced from 5.81 to 3.06.

CONCLUSION

We have described the use of Brain Wave Entrainment for tinnitus management. We believe this modality is very effective because it positively affects both habituation to reaction by its relaxing effect and the habituation to perception as a partial masker. This dual effect can be achieved because the BWE auditory stimulation is very pleasant to listen to. That enables it to provide a daily stimulation as partial masking used by TRT modality and to produce an extra relaxation effect when incorporated in the other auditory cognitive relaxation techniques.

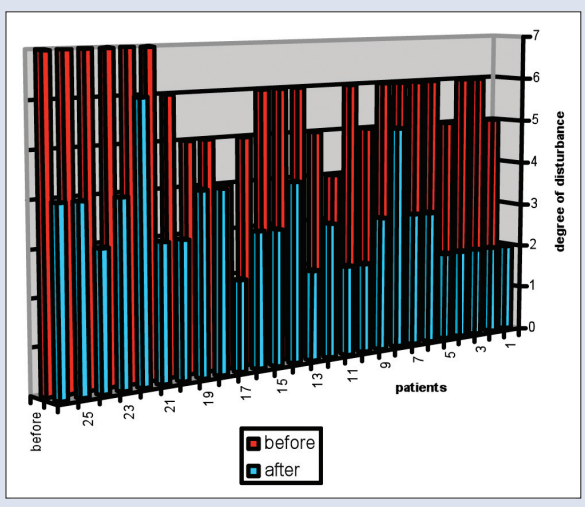

Figure 1. *Degree of tinnitus disturbance pre-treatment (in red) and post-treatment (in blue).*

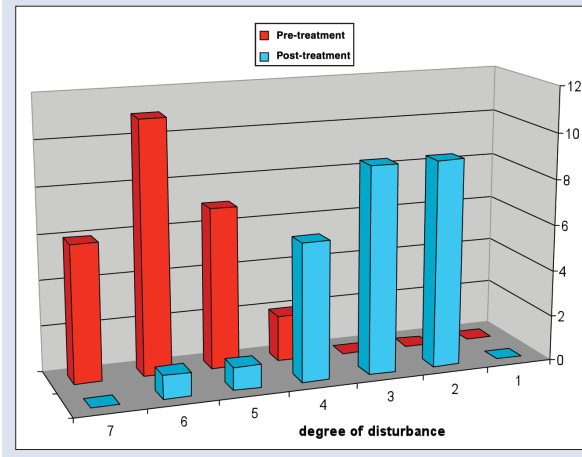

Figure 2. *Number of patients in each disturbance degree of tinnitus pre-treatment (in red) and post-treatment (in blue).*

The significant success of the participants in lowering their level of subjective tinnitus severity in such a short time supports the effectiveness of the *Tinntrain* modality.

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