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A Comparison of Nature and Technical Sounds for Tinnitus Therapy

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Summary
Sound has been used for the management of tinnitus for centuries, with broadband noise being available as a masking sound in ear-level hearing aids since the late 1970s. With the development of hearing aids designed for use with iOS and Android smartphones it is now possible to stream complex recorded sounds to listeners hearing aids. This digital streaming ability has increased the range of sounds available for sound-based tinnitus therapy. Aims: A clinical trial was undertaken to evaluate the effects of sounds of nature on tinnitus. Methods: Changes in THI and rating scales were measured in 20 patients before, three and six months following the fitting of prototype hearing aids streaming a self-selected range of sounds of nature installed on the users' smartphone. The outcomes were compared to a similar group of 17 participants receiving the same management except through conventional sound therapy hearing aids generating broadband noise. Results: The nature sounds group showed a 22.5 point THI decline over 6 months, the comparison group 21.3 points. The difference of the THI decline between the two groups was -0.62 (95% CI: -6.35; 5.12) and it was not significant (p=0.83). However, a significant (p<0.001) mean decline of 10.96 points (95% CI 8.08; 13.83) was observed per each unit of time in both groups. Conclusions: Significant improvements were obtained in both nature and broadband noise groups at three and six months following fitting. No significant difference was found between the two groups using one or the other type of sound.

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1. Introduction

Tinnitus is the perception of sound in the absence of an external sound source; it is a common auditory complaint that often accompanies hearing loss [1]. Sound, along with counselling, is a cornerstone of several approaches to tinnitus [2]. The sound has typically been presented through hearing aids. These combination hearing aids and sound generators were first developed as analogue devices in the early 1980s [3]. The rapid development of digital signal processing in hearing aids from the mid 1990s meant that these analogue devices fast became obsolete. In the last five years there has been a revival in interest in tinnitus sound therapies amongst hearing aid manufacturers; now most major manufacturers of hearing aids offer some form of tinnitus therapy device. Broadband noise has been the most common sound type used in these combination aids. The use of broadband noise has been based on the relative technical ease for generating this sound, marginal patient preference for broadband noise [4], and the belief that auditory stimulation across a broad frequency range with a neutral sound may be most effective sound to facilitate habituation [5]. The development of digital sound recording and playback methods has enabled the use of more complex sounds as therapeutic agents [6, 7].

Although the mechanisms underlying tinnitus are not fully understood, using a whole-brain approach, human neurophysiological and functional imaging studies have visualized various regions of hyperactivity in the auditory pathways of tinnitus patients [8, 9, 10, 11], as well as the activation of nonauditory cortical regions, including prefrontal, temporo-parietal areas [12, 13, 14] and limbic brain structures, such as hippocampus and amygdala [15, 16, 17]. According to several neurophysiological models of tinnitus, while the auditory system is needed for the perception of tinnitus, the limbic and autonomic ner-

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vous systems are the main systems responsible for negative tinnitus evoked reactions [18]. Recently, Rauschecker *et al.* [19] and Leaver *et al.* [20] proposed a model targeting the limbic system involvement in tinnitus. Like many researchers, they assume that the tinnitus signal initially arises from changes in the auditory system (distortion of tonotopic maps, hyperactivity of auditory neurons). However, these changes alone cannot explain why tinnitus does not occur in all cases of hearing loss, why it is intermittent in some patients, and why it can be modulated by non-auditory influences such as stress and fatigue. It is suggested that the limbic system can suppress tinnitus-related thalamo-cortical activity, thus preventing the tinnitus signal from reaching awareness. If the limbic system is overloaded from stress or fatigue, this "noise-cancellation system" fails and tinnitus is perceived [19, 20].

Sound combined with counselling has gained widespread acceptance in the audiological management of tinnitus [2, 21, 22, 23]. The beneficial effect of sound stimulation on tinnitus has been explained by the activation of neural plasticity, reversing the changes in the central auditory pathways [24, 25]. Exposure to sound induces structural and functional changes in the central auditory system but also can affect limbic regions such as the amygdala and hippocampus [26]. Sound stimulation may facilitate habituation to tinnitus by decreasing the strength of the tinnitus signal through the increase in level of background neuronal activity in the auditory system, achieved by providing an enhanced sound background. This would decrease the contrast between the tinnitus and environmental sound, thus reducing the aversive response to tinnitus [5, 23, 27]. There is controversy regarding whether sound in sound therapy should divert attention from tinnitus or not. In Tinnitus Retraining Therapy attention is not considered the crucial feature; Jastreboff suggested that the most effective sounds to achieve habituation to tinnitus are emotionally neutral with low attention capturing characteristics [23]; others have argued that psychological adaptation to tinnitus could result from moving attention away from tinnitus, eliciting positive memories to sound, and creating a positive emotional response to sound [28]. Asutay and Vasrfjall [29] reported that the same auditory stimulus was experienced as being louder, more negative, and fear inducing when it was conditioned with an aversive experience. Annerstedt *et al.* [30] described a reduced parasympathetic activation and enhanced stress recovery in individuals exposed to nature sounds compared to a control group of participants without exposure to sound.

Current sound generators and combination devices can only deliver a limited range and quality of sounds due to technical limitations including restricted internal memory. The most frequently used signals in sound therapy are simple non-information baring sounds, such as white noise, or filtered broadband noise. These noise signals can be modulated randomly to make them less monotonous to listen to and more natural sounding (6) . Because patients use sound therapy for long periods sound comfort becomes the paramount consideration. Clinical experience indicates that many patients find relief and even experience temporary remission of tinnitus while listening to natural sounds such as shower-sounds, rain, waterfalls, and ocean waves. Henry et al. (6) found that natural sounds were significantly more effective in decreasing tinnitus annoyance than technical sounds like white noise. Searchfield et al. (7) found rain was preferred as a tinnitus treatment sound over music and broadband noise by many participants, but there was a range of responses as to the annoyance and effect of each sound type.

The purpose of this study was to assess the effectiveness of wirelessly streaming sounds of nature to users hearing aids as a tinnitus treatment, comparing the efficacy of sounds of nature with conventional broadband noise sound stimulation. Because natural sounds can evoke positive connotations and are easy to accept, we hypothesized that they would improve the effectiveness of tinnitus sound therapy. To examine this concept, high-quality natural sound recordings were obtained and processed with the goal of reducing tinnitus audibility while providing a soothing response.

2. Methods

This was a randomised controlled trial. Each institution approved the methods used and informed consent was obtained and methods carried out according to the declaration of Helsinki.

2.1. Participants

Participants were recruited from clinical research centres in Milan (Fondazione Ascolta e Vivi) and Auckland (University of Auckland Hearing and Tinnitus Clinic). For inclusion volunteers had to be aged between 18 to 65 years old and a tinnitus duration of at least 6 months. Patients with objective tinnitus or conductive hearing loss, Ménière's disease or tumours of the cerebellopontine angle were excluded.

Using an electronically generated randomization schedule, tinnitus patients were randomly assigned to two groups: Group 1, assigned to receive sounds of nature and Group 2, assigned to receive broadband noise. Group 1 consisted of twenty patients, ten recruited by the clinical research centre of Milan (6 males and 4 females; mean age: 53.7 years; SD: 13.0 years) and ten by the clinical research centre of Auckland (7 males and 3 females; mean age: 55.5 years; SD: 11.0). One patient withdrew due to travel problems; so, data refers to 19 participants (12 males and 7 females; mean age: 54.7 years; SD: 12.1 years). Group 2 consisted of seventeen patients (12 males and 5 females, mean age 56.5 years; SD: 11.6 years), nine recruited in Milan (6 males and 3 females, mean age: 56.9 years; SD: 13.3 years) and eight recruited in Auckland (6 males and 2 females, mean age: 56 years; SD: 10.4).

Table I. Playlist of sounds.

File: Landscape
Acqua_BinBea_bip.wav: water from a tap
Acqua_Clean_bip.wav: water from a tap
Acqua_Rev_bip.wav: water from a tap
BoscoAcqua_BinBea_bip.wav: water in a stream in a forest
BoscoAcqua_Rev_BinBea_bip.wav: water in a stream in a forest
BoscoAcqua_Rev_bip.wav: water in a stream in a forest
BoscoVento_BinBea_bip.wav: water in a stream in a forest with wind
BoscoVento_Rev_BinBea_bip.wav: water in a stream in a forest with wind
BoscoVento_Rev_bip.wav: water in a stream in a forest with wind
Campagna_bip.wav: campaign sound landscape
Chiesa1_BinBea_bip.wav: church
Chiesa1_Clean_bip.wav: church
Chiesa1_Rev_bip.wav: church
Chiesa2_Rev1_bip.wav: church
Fuoco1_BinBea_bip.wav: fire in a fireplace
Fuoco1_Rev_BinBea_bip.wav: fire in a fireplace
Fuoco1_Rev_bip.wav: fire in a fireplace
Fuoco2_BinBea_bip.wav: fire in a fireplace
Fuoco2_Rev_BinBea_bip.wav: fire in a fireplace
Fuoco2_Rev_bip.wav: fire in a fireplace
Babble_BinBea_bip.wav: spoken in the background
Babble_Clean_bip.wav: spoken in the background
Babble_Rev_bip.wav: spoken in the background
CamminataFiume_BinBea_bip.wav: walking along a river
CamminataFiume_Clean_bip.wav: walking along a river
Chiesa2_BinBea_bip.wav: church
Chiesa2_Clean_bip.wav: church
DOCCIA LONTANA_REV: shower recorded from afar
DOCCIA LONTANO_BIN BEAT: shower recorded from afar
DOCCIA SOTTO_BIN BEAT: under the shower
DOCCIA SOTTO_REV: under the shower
DOCCIA VICINO_BIN BEAT: shower recorded close
DOCCIA VICINO_REV: shower recorded close
GOCCE MIX_BIN BEAT: water drops
GOCCE MIX_REV: water drops
UNDERWATER 1_BIN BEAT: in the rain
UNDERWATER 1_REV: in the rain
UNDERWATER 2_BIN BEAT: in the rain
UNDERWATER 2_REV: in the rain
WATEROUT_BIN BEAT: rain
WATEROUT_REV: rain
BARCA BIN_BEAT: sound of the sea from a boat
BARCA REV: sound of the sea from a boat
DOCCIA BIN_BEAT: shower
DOCCIA REV: shower
PIOGGIA DEBOLE BIN_BEAT: light rain
PIOGGIA DEBOLE REV: light rain
PIOGGIA FORTE BIN_BEAT: heavy rain
PIOGGIA FORTE REV: heavy rain

2.2. Recording of sounds of nature and post processing

A collection of natural sounds was obtained using high quality recordings. The sound recordings were recorded at a sampling rate of 44.1 kHz per channel, with a flat microphone response, using a dummy head to preserve spatial cues. The sounds were from natural soundscapes that had a psychologically soothing effect on the researchers (e.g. the sound of running water, the interior of a cathedral, the background sound of a forest, being in the countryside and near a river, a water fountain inside a room, the sound of a shower and ocean waves). The sounds had a wide frequency spectrum. For each setting audio sequences of appropriate length were selected that could be heard without obvious repetitions when looped. Normalization was carried out at 0 dB FS (at 24-bit resolution) amplitude maximum peak (peak amplitude), using the Audacity software "Normalize" function. Stages of normalization: Remove DC offset (center vertically on 0.0); Normalize maximum amplitude to 0.0 dB. All tracks were equalized to 0 dB, appropriately cut for the listening loop and saved in Android or iOS audio format. A playlist of 54 sounds (Table I) was available to participants in the nature sounds group to be uploaded to an iOs or Android smartphone for sound streaming to the prototype combination devices.

2.3. Audiologic testing

At the first visit, all of the participants underwent a complete audiological and external ear evaluation including a full history and physical examination, pure-tone audiometry, immittance testing and tinnitus measurement. Pure-tone audiometry was performed in a sound-attenuated booth. Hearing levels were measured in each ear separately at 0.25 – 8 kHz, at half octave steps for air conduction and at 0.5 - 4 kHz for bone conduction. The Pure Tone Average (PTA) at 0.5, 1, 2 kHz was calculated. In addition, we studied the high frequency range that is usually impaired in tinnitus patients. The High-Frequency Pure Tone Average (HF-PTA) was calculated by averaging thresholds per ear obtained at frequencies of 4, 6 and 8 kHz. In this report, normal hearing was defined as a PTA equal to or lower than 20 dB HL. The degree of hearing loss was classified as “mild” when the PTA was between 21 and 40 dB HL, “moderate” between 41 and 70 dB HL, “severe” between 71 and 90 dB HL and “profound” more than 91 dB HL.

Tympanograms were recorded using a 226-Hz probe tone and classified as type A, type B, type C, type As and type Ad [31] . In patients with type A tympanograms, the contralateral Acoustic Reflexes was determined.

Tinnitus measurements included the Tinnitus Handicap Inventory (THI) questionnaire, in the Italian version in Milan [32] and in the English version in Auckland [33] and a Numeric Rating Scale (NRS) for annoyance (between 0 to 10 with 0=not annoying and 10=extremely annoying).

2.4. Sound therapy

A counselling session was provided before starting the sound therapy, this included a clear explanation of the physiology of hearing and present knowledge about tinnitus generation and perception, as suggested by Jastreboff [34].

Table II. Baseline Audiological parameters and subjective Tinnitus Characteristics. PTA refers to pure tone averages of 0.5-1-2 kHz and HF-PTA to pure tone averages of 4-6-8 kHz. In paranethesis: Standard deviation.

Characteristic	Group 1 Nature sounds	Group 2 Broadband noise
Number	19	17
Gender	12 M/7 F	12 M/5 F
Age (years)	54.77 (12.1)	56.5 (11.6)
Right PTA (dB HL)	17.3 (12.3)	20.3 (11.1)
Left PTA (dB HL)	17.3 (12.4)	22.8 (13.1)
Right HF-PTA (dB HL)	41.1 (22.7)	41.1 (17.0)
Left HF-PTA (dB HL)	45.3 (21.9)	45.9 (18.7)
Tinnitus Pitch (kHz)	8.1 (3.4)	10.6 (1.9)
THI	43.9 (16.2)	52.2 (13.9)
NRS (annoyance)	6.4 (2.1)	6.1 (1.7)

Participants in Group 1 were fitted with bilateral prototype ReSound combination hearing aids connected wirelessly (using a Bluetooth streamer, Resound Phone clip 2) to the users smartphone containing the nature sounds. Participants were free to choose their preferred sound and change it during trial if desired. Participants in Group 2 were fitted with standard combination aids (Resound Live TS or Alera TS, Verso TS) with broadband noise generator. The devices for both groups had the same frequency range. Sounds of nature were presented in stereo.

In order to standardize hearing aid fitting across the two centres, we used the prescription formula suggested by Aventa and in situ measures to verify the amplification delivered. All patients were instructed to set the sound level at the lowest comfortable level that mixing of the treatment sound and tinnitus occurred, and to use the device as much as possible, but at least 8 hours per day. All participants received the same counselling at the fitting and 1, 3 and 6 months following fitting and whenever requested by the patient.

Tinnitus treatment outcomes were assessed three and six months after commencing treatment. During the follow up visits, the THI and the NRS were administered in order to quantify sound therapy benefit.

2.5. Primary and secondary outcome measurements

Primary measure: THI change over time. THI scores were measured across baseline, 3 months and 6 months post fitting in both groups.

Secondary measure: NRS change over time. NRS scores were measured across baseline, 3 months and 6 months post fitting in both groups.

2.6. Power analysis

Since 17 resulted to be the standard deviation of the THI change over time at the end of the study, having fixed type I error to 0.05, a study size of 18 patients per group has a 80% power in detecting a minimum clinical relevant effect (difference of THI change over time at the end of the study between the two groups) of 16.

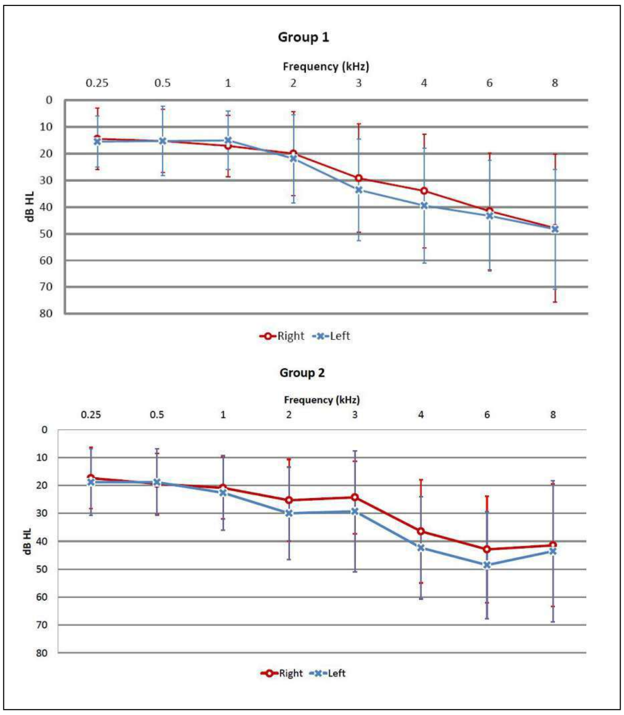

Figure 1. (a) Mean air conduction thresholds and standard deviation of right and left ear in Group 1 patients. (b) Mean air conduction thresholds and standard deviation of right and left ear in Group 2 patients.

2.7. Statistical analysis

We reported results as mean ±SD. We fitted two-level models to the THI profile over time (with patients as a random term). We tested whether the treatment had any effect on the decline of THI over time. In the final model the effect of hearing level (a possible confounder for the association between the treatment and THI) was not included since the effect of this variable on THI decline was negligible. Similarly, two-level models were fitted to the profile of NRS over time. Statistical analysis was performed with SAS software version 9.2. (Copyright, SAS Institute Inc., Cary, NC, USA).

3. Results

The tinnitus and demographic characteristics of both groups are reported in Table II. The mean air conduction thresholds and standard deviation of right and left ear for both groups are illustrated in Figure 1.

In the group receiving nature sound therapy 13 tinnitus patients had normal hearing levels based on the PTA (PTA $\leq$ 20 dB HL) with hearing impairment in the high frequency range (HF−PTA > 20 dB HL) and 6 a mild/moderate hearing loss (4 bilateral and 2 unilateral); tinnitus was unilateral in 16 patients (11 right, 5 left) and bilateral in 3. In the comparison group receiving broadband noise stimulation 8 tinnitus patients had normal hearing levels based on the PTA (PTA $\leq$ 20 dB HL) with hearing impairment in the high frequency range (HF−PTA >

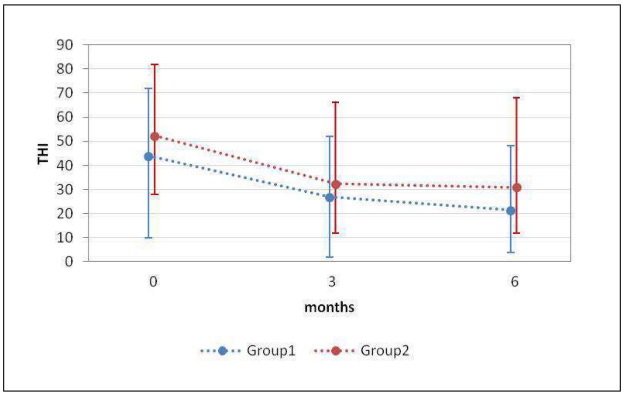

Figure 2. Mean THI scores over time of Group 1 and Group 2 patients. Whiskers show maximum and minimum levels.

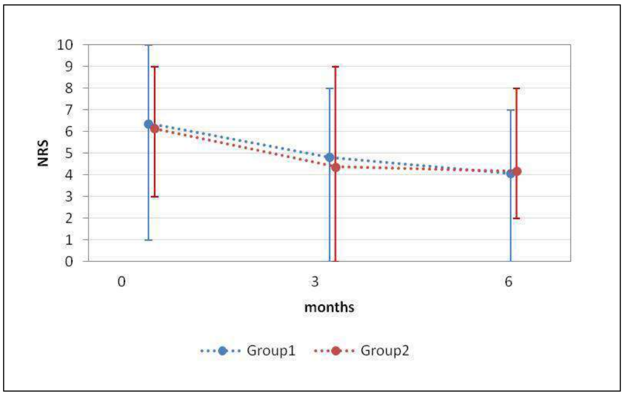

Figure 3. Mean NRS scores over time of Group 1 and Group 2 patients. Whiskers show maximum and minimum levels.

20 dB HL), 7 a mild hearing loss (4 bilateral, 3 unilateral), 1 a mild hearing loss in one ear and a moderate hearing loss in the other and 1 a moderate bilateral hearing loss; tinnitus was unilateral in 13 and bilateral in 4 participants.

3.1. Primary measure: change of THI

Mean THI scores across baseline, 3 months and 6 months post fitting are shown in Figure 2. In Group 1 the average THI values were 43.9 (SD 16.2) at baseline, 26.9 (SD 14.9) at 3 months and 21.4 (SD 14.2) at 6 months. In Group 2 the average THI values were 52.2 (SD 13.9) at baseline; 32.4 (SD 15.2) at 3 months and 30.9 (SD 15.1) at 6 months. The nature sounds group showed a 22.5 point change over 6 months, the comparison group 21.3 points. We divided each group into two subgroups, with and without hearing loss (Table III). For Group 1 the mean THI values in normal hearing patients were 42.6 (SD 17.2) at baseline, 25.1 (SD 14.9) at 3 months and 18.8 (SD 12.8) at 6 months and in hearing impaired patients were 46.7 (SD 14.9) at baseline, 31.0 (SD 15.4) at 3 months and 27.0 (SD 16.6) at 6 months. For Group 2 the average THI values in better hearing patients were 50.7 (SD 5.9) at baseline 270. (SD 14.3) at 3 months and 22.0 (SD 12.3) at 6 months and in hearing impaired patients were 53.6 (SD 18.8) at baseline, 37.1 (SD 15.2) at 3 months and 38.9 (SD 13.1) at 6 months. Hearing level had no effect on either the baseline THI or on the THI decline, therefore we did not consider the hearing levels in the final model. The difference of the THI decline between the two groups was -0.62 (95% CI: -6.35; 5.12) and it was not significant ($p=0.83$). However, we observed significant ($p<0.001$) mean decline of 10.96 points (95% CI 8.08; 13.83) per each unit of time in both groups.

3.2. Secondary measure: change of NRS

Mean NRS scores across baseline, 3 months and 6 months post fitting are shown in Figure 3. In Group 1 the average annoyance values were 6.4 (SD 2.1) at baseline, 4.8 (SD 2.0) at 3 months and 4.1 (SD 2.0) at 6 months. Group 2 results were 6.1 (SD 1.8) at baseline, 4.4 (SD 2.4) at 3 months and 4.2 (SD 2.0) at 6 months.

Hearing level had no effect on either the baseline NRS or the NRS decline, therefore we did not consider the hearing levels in the final model. The difference of the NRS decline between the two groups was -0.16 (95% CI: -1.06; 0.74) and it was not significant ($p=0.72$). However, we observed significant ($p<0.001$) mean decline of 1.07 points (95% CI 0.62; 1.51) per each unit of time in both groups.

The nature sounds participants chose the following sounds: 6 users chose shower sounds, 6 rain, 3 ocean waves, 3 wind in woods, 1 creek and 5 patients didn't have a clear preference. The majority of participants found the sounds to be comfortable and did not find the use of sound tracks disturbing at work or in social conditions. The sounds were reported as very pleasant and relaxing and the majority of the patients were happy to use them 24hours/day. The only qualitative concern was that the Combination aid's battery life was limited to 4 days, due to the continuous streaming from their smartphones. Even people that were unaccustomed to the use of mobile computing easily accepted the use of the smartphone.

4. Discussion

This study compared the effect of sounds of nature to conventional broadband noise stimulation on tinnitus. Significant improvement was achieved after three and six months of use for both natural sounds and broadband noise groups, but there was no difference between the two groups. Participants in the natural sounds group indicated preference for running water sounds. This observation is consistent with other studies that suggest nature sounds can have positive effects on tinnitus. Although users of the sounds of nature found them helpful the benefits did not extend to a greater reduction in tinnitus than the usual treatment. This suggests that the presence of sound is important, and not its specific parameters. This is in line with previous studies reporting benefit from sound therapy. Hazell [35] concluded that users found sound therapy devices subjectively helpful and reported lower levels of tinnitus annoyance with their use but found no significant difference between sound therapy devices, hearing aids or combination

Table III. Age, PTA and HF-PTA values of the two subgroups – normal hearing and hearing loss – of Group 1 and Group 2 patients. In parenthesis: Standard Deviations.

				PTA (dB HL)		HF – PTA (dB HL)	
		N	age (years)	right	left	right	left
Group 1	Normal hearing	13	51.8 (13.3)	10.5 (3.8)	10.7 (4.1)	30.8 (17.1)	36.5 (18.7)
	Hearing loss	6	60.8 (5.7)	32.2 (11.0)	31.6 (12.3)	63.6 (16.2)	64.2 (16.3)
Group 2	Normal hearing	8	55.0 (11.7)	12.5 (3.8)	11.8 (3.9)	41.0 (18.5)	37.2 (16.2)
	Hearing loss	9	57.8 (12.2)	27.4 (10.7)	32.6 (10.2)	41.2 (16.6)	53.7 (18.1)

instruments. The design of the study does not enable us to ascertain why the two groups did not differ in outcomes.

The sounds may simply have been equally effective maskers. It is also plausible that the similar effects measured were the result of different but equally effective mechanisms (e.g. improved reaction to tinnitus compared to simple habituation). Both groups were of similar age and tinnitus severity. The hearing level of participants had a negligible effect on THI decline, thus supporting that TRT is equally effective to patients with and without hearing loss. However the personality of participants was not assessed and this has recently been suggested as a predictor of sound based tinnitus adaptation [36] and might influence sound selection.

Six months was considered a reasonable assessment period, it has however been shown that some sound therapy effects may not differentiate until after 12–18 months [37]. Consequently longer-term trials may be necessary. It is possible, but an untested hypothesis, that THI scores might continue to improve after 6 months in response to sounds of nature. Future studies should also look at changes occurring immediately post-fitting (within weeks, rather than months): it is possible that the rate of improvement is superior for one treatment over another. Such a study may assist in differentiating more immediate effects of masking from longer-term psychosocial changes. A cross-over trial with the same participants acting as their own control may provide clarity as to whether individual sound selection was equivalent or superior overtime. In this study the emphasis was on ascertaining if selection of treatment sounds from many options (54) would be better than broadband noise. Next-steps in the valuation process should be to look at factors determining individual selection of sounds and factors contributing to success (e.g extent of masking and volume preference).

We did not examine the spectra and energy of various sounds. We realize that this could represent a problem in the interpretation of the results but its impact is decreased by the level at which patients were instructed to set the sound, a level below sound annoyance.

Also, nature sounds were presented in stereo, while the broadband noise was generated separately at each ear as mono signals. While this difference could have implications for the treatment outcome we cannot judge how relevant this dimension is. Nevertheless, it might be considered another variable along with many others that distinguish nature sounds from technical sounds (for example temporal variations, variable frequency content). In this context a stereo signal is one further difference in the nature of sounds used.

The only negative comment received from the trial of the streamed sounds of nature was high battery drain. Such technical limitations have already been reduced in next generation wireless designs and are likely to continue to improve with technology evolution.

The present study set out to investigate whether sound therapy with sounds of nature is effective in the management of patients suffering from tinnitus compared with technical sound. In order to test this hypothesis, we employed natural sounds that were considered psychologically soothing. The technical procedures used to record and edit the sounds were designed to improve the relaxing power by providing a sense of presence in the virtual sound environment. Among a selection of natural sounds, the patients involved in this study chose sounds of water, rain, shower, creek and ocean waves. This preference is in line with the conclusions of Henry *et al.* [6] that used different custom sounds for achieving tinnitus relief and stated that nature and water sounds were significantly more effective than the other sounds in reducing tinnitus annoyance. As far as the impact of sounds of nature on anxiety and depression, we collected only subjective information and comments from the patients that indicated appreciation of the natural sounds, self-reported as having a positive side effect on the anxiety level. No negative side effects were reported to the sounds of nature. Most of our patients found the sound tracks very comfortable and they did not report any difficulty in speech understanding. The effects of natural sound recordings on the intelligibility of speech in sound therapy are minor compared to broadband noise. According to Paglialonga *et al.* [38] at the same stimulation level, speech intelligibility was lower for broadband noise than for a moving water recording.

5. Conclusions

This trial demonstrated that there are no significant differences between nature and technical sounds in the management of patients suffering from tinnitus. However significant improvements were obtained in both groups at three and six months following fitting. Future research should address the influence of nature sounds on the different aspects of auditory processing, tinnitus perception, anxiety and depression.

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