Hearing aids have been used to treat tinnitus since the 1940’s. Hearing aids combined with sound generators for masking became available in the early 1980’s. Because tinnitus is often accompanied by hearing loss, engineers and researchers have tried to address both problems simultaneously. The availability of digital signal processing and hearing aid compatibility with smartphones has seen new sound therapy ideas emerge. Sound therapy is the use of sound to assist tinnitus. While different sound therapies have been made possible by new hearing aid technology often the evidence for effectiveness is weak. A scan of the literature published in 2016 was undertaken using the terms “tinnitus” and “hearing aids” [or] “combination” [or] “instruments”.

Commercially available devices
Aazh and colleagues [1] undertook a survey of patients’ views of the effectiveness of the interventions provided by the Tinnitus and Hyperacusis Therapy Clinic at the Royal Surrey County Hospital. The survey found that 64% of respondents found hearing aids were useful or very useful. These patients also received counselling making interpretation of the relative contribution of treatment components difficult. Several small studies from Brazil looked at the benefits of hearing aids [2][3] and combination devices [4][5][6]. The study designs didn’t allow for strong conclusions to be made, but the authors believed the results were consistent with the devices reducing tinnitus.

Another small-scale study, investigating the feasibility of evaluating a combination device, was undertaken in the UK [7]. The trial aids were set with 4 programmes:

- Amplification
- Amplification and masking noise (with manual volume control)
- Amplification and masking noise (with automatic adjustment)
- Amplification and ocean sound (with manual volume control).
Although the study only had eight participants, it did make some interesting observations. Preferences for sound varied across environments, and while the noise was the most effective masker, the ocean sound provided distraction and/or was relaxing. The authors suggest that flexibility is needed in fitting these devices to suit each individual’s preference.

A larger study that demonstrated the benefits of hearing aids for tinnitus also provided interesting insight into the potential mechanisms of effect [8]. The effects of hearing aids on a group with tinnitus and hearing loss were compared to a group with just hearing loss. The results showed improved sleep and hearing with reduced tinnitus following hearing aid use. Interestingly, concentration (using a reading span test) also improved in tinnitus patients after hearing aid use. The authors concluded:

“...hearing aid fitting should be a central part of tinnitus treatment in patients with both tinnitus and hearing loss” (p 150).

**Notched environmental sound**

Tailor-made notched music is a treatment proposed to suppress tonal tinnitus by a lateral inhibition mechanism [9]. A filter is applied to music of the listener’s choice at their tinnitus pitch-matched frequency (the notch). The method has been used with encouraging results. A modification of this concept was trialled in which notched filtering of environmental sound was used instead of music [10]. A group of 10 participants trialled the notched environmental sound compared to 10 controls using standard amplification. The group receiving notched amplification showed greater improvement in the Tinnitus Handicap Questionnaire (THQ) [11] over three weeks than normal amplification. The concept is an interesting one that requires further evaluation in larger numbers of participants over a greater time period, and with consideration of effects of notching on speech perception.

**Spatial masking**

The use of sound to partially or fully mask (cover) tinnitus has focused on the appropriate level and spectrum of sound to interfere with tinnitus. Another aspect of masking in real-world situations is where the sound is located. A masker that has the same location as a target sound is more effective than if they are separated in space. This was the topic of an iterative series of small studies [12]. The studies explored whether masking sound localised (using interaural timing and intensity changes and Head Related Transfer Function [HRTF]) to the same location as a person’s tinnitus (eg “right-side towards front of head”) would be more beneficial than conventional masking. The first study used headphones then the method was applied using hearing aids. The results indicated variation in preferences but across all three studies the modified spatial masking was preferred. As with many of the studies reviewed here, larger sample sizes and longer treatment times would help clarify effectiveness.

**Nature sounds**

The convergence of hearing aid and smartphone technology now enables hearing aid users to stream sound from their personal music library to their hearing aids via Bluetooth connections. Most hearing aid manufacturers have developed apps (mobile applications) for this purpose and there are various websites where sounds for tinnitus treatment can be accessed.

BaroZZi and colleagues [13] hypothesised that nature sounds would evoke more positive emotional responses than noise and this would improve the response to treatment. A multisite trial was undertaken comparing a group (17 participants) using combination aids with conventional broadband noise to a group (19 participants) using similar hearing aids but streaming...
user-selected nature sounds. Significant improvements in the Tinnitus Handicap Inventory (THI) [14] were achieved at three and six months compared to baseline, but there was no distinct advantage of one sound type over another. The preferred nature sounds were some form of running water. It was not explored if certain sounds (e.g. with relaxing qualities) may be more beneficial for some persons while other sounds (e.g. more effective in masking such as broadband noise) might benefit others more.

Music
Music has been used in various forms as a therapeutic tool for tinnitus. Some of these therapies modify the music in order to compensate for hearing loss, so as to ensure audibility of the treatment sound. The Heidelberg model is a music therapy; the treatment does not use passive exposure to sound: instead a music therapist guides vocal exercises in response to music and relaxation exercises over five consecutive days [15]. The music is not adjusted for audibility (music is live, played on a piano). This raised the question as to whether persons with hearing loss would benefit more from the therapy if they wore hearing aids? Three groups of 40 participants were compared, one with hearing loss and hearing aids, one with hearing loss and no aids, and a normal hearing group. The normal hearing group and the group with hearing aids showed greater improvement in Tinnitus Questionnaire (TQ) [16] scores than the group with hearing loss but no aids. For full potential of the treatment to be met, patients with hearing loss should be using hearing aids.

Conclusions
The research published in 2016 demonstrates the value of hearing aids across different treatment settings. It also identifies that many of these novel treatments are at developmental stages. Digital signal processing has facilitated many novel approaches for sound therapy using hearing aids and combination instruments. Although the majority of studies use small samples, and so provide low levels of evidence, they are necessary to provide proof of concept and feasibility for future randomised controlled trials (RCTs). RCTs for hearing aids are expensive and when the developments have commercial potential the onus is often on companies, as opposed to government and not-for-profit organisations, to fund trials. The research also hints towards the very individual nature of sound therapy and the different mechanisms (masking, relaxation and cognitive benefits) that different sound types may have. My “take home” message from reviewing 2016’s publications on hearing aids and combination devices for tinnitus is that we need to carefully consider each patient’s cognitive, emotional and perceptual needs in selecting sound therapy.
References


Conflict of interest. Grant Searchfield receives research funding from, and has commercial interest with, hearing aid manufacturers. Some of that research is described in this article. He is clinical director of Tinnitus Tunes a subscription-based tinnitus treatment website.