Is There Benefit for Auditory Training with Hearing Aid Users

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ABSTRACT

Hearing loss has long been a stigma which has been linked to depression and anxiety, it originates from how a person hears in social occasions, where the increase in background noise makes it increasingly difficult to hear and interpret speech. This is where hearing aids have been used to help increase speech recognition. However, even with the advancements in technology there is still room for improvement. Auditory training could be the solution and has been offered to people with hearing loss for many years, but is not seen as cost effective to provide in professional clinics and can have inconsistent results. Increasingly affordable technology and computer based auditory training programs could be included into current rehabilitation programs to help improve hearing aid users' ability to understand speech in noise.

In this study we undertake a review of current literature that investigates auditory training programs provided to adult participants with hearing loss fitted with hearing aids to understand if there is an improvement in speech understanding and recognition in noise. This review looked at studies that included a cross-over pilot, randomised controlled trials and repeated measures. Forty articles were found in relation to auditory training of which sixteen were evaluated and five selected for this review. The articles reviewed showed a mixed set of results with the benefits of auditory training for hearing aid users showing some improvement, however the evidence is low. Future research is needed with a larger number of participants, to determine whether auditory training is beneficial for hearing aid users and if it can be implemented effectively in a professional clinical practice.

INTRODUCTION

It is commonly understood that, in the elderly population, hearing in background noise is a complex listening environment and is a challenging situation, with the person being unable to understand what is being said which can mean they disengage from the conversation entirely (Henshaw & Ferguson, 2013). Hearing loss is estimated to affect over 466 million people worldwide, which equates to over 6% of the world's population, with the vast majority, 93%, being adults. This figure is expected to continue to grow, and by the year 2050, over 900 million people will be affected (World Health Organisation, 2018). The WHO estimates that a third of the people aged 65+ are affected by disabling hearing loss. When looking at hearing loss, it can be categorised into levels of loss: mild, moderate, severe and profound. This can lead to a number of issues, one of which is to make a person feel social anxiety (Moon, Park, Jung, Lee, & Lee, 2018).

A person with hearing threshold of greater than 25dB is deemed to have a hearing loss, and a debilitating hearing loss is described by the WHO as a person with a hearing threshold greater than 40dB (World Health Organization, 2020). The most common hearing loss observed is a sensorineural loss. This is caused when there is damage to the inner ear hair cells or the auditory nerve, this can be due to age, noise exposure or other causes (Starkey, 2020). If hearing loss is left untreated it can be found to have a negative effect on a person's quality of life and can cause cognitive and functional decline, social isolation, higher risk of falls, decreased social and emotional function, and communication decline (Abrams, Bock, & Irey, 2015). The first strategy to treat hearing loss is generally hearing aids, to help increase the person's ability to hear and to try to help them feel socially engaged again.

Hearing Aids have seen a seismic increase in technology over the last 20 years with continued improvements being made daily. However, hearing aids improvements and client satisfaction have not always gone hand in hand. It is seen in some research that only 74% of clients are satisfied with their hearing aids and 26% being unsatisfied (Kochkin, 2007). This can be due to several issues, however the most prevalent is the person's ability to hearing in complex sound environments (Kochkin, 2007). This being stated, complex sound environments with competing speakers and loud background noise can be difficult for people with normal hearing, let alone people with hearing impairment. Traditionally hearing aids with directional microphones are used to help increase the signal to noise ratio; however, this is not always met with success (Bock & Abrams, 2014). When a person wears a hearing aid, is vitally important for them to achieve some form of success with their device. This can often be the difference between the person wearing their hearing aid successfully or contribute to their failure to use the hearing aid at all. Through validation and verification techniques, as well as a set hearing plan, with follow up appointments for amplification adjustments, generally a positive outcome will be observed. The research into the benefits of aural rehabilitation supplied by the clinic through post-fitting rehabilitation services are starting to be seen (Bock & Abrams, 2014).

Aural rehabilitation is more specifically seen as auditory training. The premise of this training is to try and achieve better results for

clients and increase their satisfaction and adaption to their hearing aids (Bock & Abrams, 2014). Auditory training can be defined as a purposeful and systematic presentation of sounds such that listeners are taught to make perceptual distinctions about those sounds (Schow & Nerbonne , 2007). Through this training, there has been some noted improvements in speech understanding; however, there is also the challenge of clinical time and the effectiveness of the training to produce the required results (Olson, 2015). The increase in technology and a person's technical abilities have led to the rise of providing computer-based auditory training programmes at home, this then has the potential to decrease the clinic time needed for the clinician to interact with the client conducting the training (Chisolm, et al., 2013). These training programmes such as listening and communication enhancement (LACE) are becoming more prevalent, however compliance and getting the training completed can sometimes be an issue. No matter the type of programme used, the basic premise of auditory training is the same, it involves listening tasks which are generally lists of sentences, words or speech syllables presented in noise, these tasks are repeatedly listened to at home via computer-based programme or in a clinic using live speech, recordings or computer programmes. Despite the wide variety of the programmes they are all designed to help improve communication ability (Brouns, El Refaie, & Pryce, 2011). The concept behind auditory training is based on the ability of the auditory cortex to reorganise in response to sensory experience (Bamiou & Luxon, 2008). Plasticity in the brain enables neuronal pathways to develop from response to environmental stimulus, there is a greater degree of plasticity in childhood, however this is still retained into adulthood (Brouns, El Refaie, & Pryce, 2011). Sensory deprivation has been seen in people with hearing loss, whilst hearing aids can only help the cochlear hear, it cannot repair the auditory processing system alone. This is where the theory of auditory training is applied, the exercises of repeated and varied listening tasks provide stimulus to help reorganise the central auditory system and improve speech understanding (Brouns, El Refaie, & Pryce, 2011).

As previously stated, the number of people with hearing loss is expected to continue to grow over the next 30 years so it is important that measures are taken to help people hear with clarity. The advancements in hearing aids will continue, and sales of hearing aids are growing as well however, there will always be an issue with hearing conversation in noise (Olson, 2015). This is where effective auditory training methods could fill the gap, to improve satisfaction, as technology becomes more available, in-home computer-based training programs such as CBAT, are ideally placed to help rectify some the issues faced with providing auditory training in a clinical setting. Research in auditory training does show that there can be improvement in speech understanding when the training program is completed which is promising (Abrams, Bock & Irey, 2015; Bock & Abrams, 2014; de Miranda, Gil, & Iorio, 2008; Henshaw & Ferguson, 2013).

The purpose of this systematic literature review is to determine if there are benefits if a practice incorporates auditory training programmes in the aural rehabilitation for hearing aid users. With an aim to increase device satisfaction levels, more than the current standard hearing aid fitting

procedures. This is so we can understand whether the training programs are worthwhile to develop in clinical practices. The research question posed: "Is auditory training programs a benefit for hearing aid users rehabilitation process and does auditory training increase their speech understanding"?

METHOD

Type of studies

When selecting the studies for this literature review, several criteria were considered. The studies need to have reliable testing, with an evidence base of at least 14 participants. The testing needed to use one of the following methods: randomised selection, repeated measure design, or before and after comparison of results. If the study did not meet this criterion it would not be used in this review and will be discarded.

Participants in study

The participants used in these studies were adults 18 years and above. They needed to have a mild to moderate symmetrical sensorineural hearing loss, ranging in pure tone audiometry from 21dB HL to 70dB HL. The adults in the trials must use hearing aids, but there were no requirements about whether they were first-time users or experienced hearing aid users. The studies reviewed used adults aged 46 years up to 90 years of age. The number of participants varied across the studies from 14 to 40 people. All studies selected met the participant requirement.

Interventions in Study

The types of interventions used in the studies were all different, however they were all required to have an auditory training method involved. The auditory training often involved training sessions that were attended in person with a trainer, or internet training programs depending on what training program was being implemented. All articles required the participant to complete tasks, whether this was listening to a CD, story or listening and memory tests. These sessions ran from 3 weeks to 6 months depending on the research methodology. Every study, however, did have sessions at least every week for the participants to attend.

Outcomes used in Study

These research articles used several different outcome measures. All outcome measures were used to determine whether the participant hearing outcomes improved from their auditory training. The research by Nkyekyer et al., (2019) used Blamey Saunders SPT, and Subjective Assessments of Hearing (APHAB). Henshaw et al., (2013) used Competing Speech Task, Letter-Number Sequencing Task, Dual-Task of Listening and Memory, with baseline measures taken at the start of the training and after the training sessions. Chisolm et al., (2013) used Words in Noise test, Nu No.6 words, modified NU-20 Completing Message Test, an Audio-Recorded Version of Digit Span Subtest of the Wechsler Adult Intelligence Scale, Revised Speech in Noise Test. Gill et al., (2008) used SNR testing (SRPN), Non-Sensitized Speech Recognition Index Test, Speech Test with White Noise and Hearing Handicap Inventory for the Elderly-HHIE, to grade the participants improvement. Abrams et al.,

(2015) used Abbreviated Profile of Hearing Aid Benefits (APHAB), Hearing in Noise Test (HINT), Word in Noise Test (WIN), Device-Oriented Subject Outcome Scale (DOSA), to determine any improvements.

Search Strategy

A review of academic databases was undertaken using keywords relating to the topic. These databases included, PubMed, ASHA Wire, Science direct, ResearchGate, Sage Journals, Google Scholar and Microsoft Academic. When searching these academic databases, a combination of keywords were used relating the topic such as; “Auditory Training”, “Auditory Training Therapy”, “Hearing Aid”, “User”, “Adult”, “Hearing Loss”, “Speech Recognition”, “Speech Intelligibility”, “LACE”, “Rehabilitation”, “Auditory Rehabilitation”, “Communication Training”, “Aural Rehabilitation”, “Speech understanding”, “Speech discrimination”, “Computer based speech training”, “Computer based auditory training”. The search criteria required the age of publication to be within the last 20 years and was limited to adult participants using hearing aids.

Selection of Studies

A thorough search of online academic databases was conducted using the described key words. After this search, 40 articles were found that may have met the selection criteria. Each abstract was read, which lead to 24 of these articles being discarded. This was due to the age of the article or the use of children as the participants instead of adults. The remaining 16 journal articles were then read in more detail, with a further 11 articles discarded, due to participant numbers, or control methods used. The remaining 5 journal articles met the search criteria and provided a good scope of auditory training for adults with hearing loss and using hearing aids.

Extraction of Data

The 5 review articles were analysed for specific information so a cross analysis could be conducted. This information included; the type of study conducted, the participants used, age and gender, number of people in the trial, hearing loss requirements for the study, the average hearing loss of the participants, participant dropout rate, completion of activity, hearing aid use (whether they are first time users or short term users), the type of hearing aid user, the hearing aid specifications and adaption process, the outcome measures and intervention type, the period of intervention and session times. This information was used for cross evaluation of the articles.

Assessment of Quality

To understand the quality of the articles it was necessary to set criteria to cross compare the studies. As each study uses a different outcome measure and different interventions, it is not possible to group them by this means. However, the following criteria were applied; the study type, participants dropout rate, outcome measures specified, and if the study had ethics policies in place.

Type of study: 4 of the studies reviewed are randomized control, one of which is blinded (Abrams, Bock, & Irey, 2015; Chisolm, et al., 2013; Nkyekyer, Meyer, Pipingas, & Reed, 2019; de Miranda, Gil, & Iorio, 2008). The other study uses repeated measure design (Henshaw & Ferguson, 2013).

Outcome measures: outcome measures were available for all articles expect for the study that uses repeated measure design.

Ethics Policy: the policies used in the studies are specified in 3 articles; however, they are not discussed in the remaining 2 articles.

(See Table 1.)

RESULTS

The five studies analysed for this literature review have showed different results, as all the studies have different variables, procedures, outcome testing and interventions. There was consistency in the selected studies of auditory training, focusing on a face-to-face or computerised model of application. All the cases looked at hearing aid users and the benefits of auditory training. An explanation of each study is provided with information causally relating to their specific study to help analyze the data and results.

Nkyekyer et al Study Results

In this study, the aim was to see if auditory training combined with hearing aid use could improve cognition and psychosocial functions in adults with hearing loss (Nkyekyer, Meyer, Pipingas, & Reed, 2019). This paper was a randomised cross-over pilot study which looked at 40 people with little hearing aid usage and supplied them with hearing aids for 3 months but provided auditory training for 6-months, the first 3 months of training was unaided. The training program, consisting of weekly face-to-face training using the continuous discourse speech tracking, the sessions lasted for 15 minutes. The participants were aged between 50-90 and had a hearing loss range between 25-70dB. This study used Blamey Saunders SPT, APHAB, SUCCAB and the GDS. Through the course of this study 9 participants dropped out of the study, the results from these participants were excluded from the final analysis. The study found significant improvements in depressive symptoms with a moderate to large effect size, as well as a significant deterioration in aversiveness of sound when hearing aids were worn. This report also found that hearing aid usage was associated with improvements in speech perception, and increased the audibility of the sounds (Nkyekyer, Meyer, Pipingas, & Reed, 2019).

Henshaw et al Study Results

The purpose of this paper was to identify appropriate outcomes for the functional benefits of auditory training for real world adults who wear hearing aids and have a mild to moderate sensorineural hearing loss. This study used a repeated measure design which looked at 30 adults aged 50-74 who had hearing aid experience and a hearing loss range of 21-69dB HL (Henshaw & Ferguson, 2013). The study was conducted using two baseline outcome assessment sessions to account for procedural learning effects on outcome measures. Then one week of no contact and a second assessment session. After these two baseline sessions participants were given at home training for one week, consisting of two 15-minute training sessions for seven consecutive days. The auditory training was phoneme discrimination in noise tasks, competing speech tasks and letter number sequencing tasks. Throughout this study, the participants completed 197.8 minutes of at home training. The report did not specify if there were any dropouts during the process. The results showed a significant improvement in

phoneme discrimination in noise tasks thresholds over time; however, there was no significant improvements for three of the four trained phonemes that had the poorest threshold (Henshaw & Ferguson, 2013).

Chisolm et al Study Results

The study was designed to look at compliance and outcomes of LACE auditory training for veterans who wear hearing aids. This paper is randomised controlled trial which identifies 50 participants aged from 58-85 years old who had a hearing loss PTA in the left ear of 47.6dB and right of 46.0dB. To be eligible for this study the adults had to be hearing aid users (Chisolm, et al., 2013). The participants in this study were given at home LACE training data for tasks, Speech in Babble, time compression, competing speaker, auditory memory and missing words. The study started with a baseline outcome measure, the group was then given computers and speakers to ensure standardisation across the group and commenced the LACE training sessions, which consisted of one session daily, 5 days per week until all 20 sessions provided were completed. The participants were then scheduled for outcome measures 4-6 weeks after the initial measure. Forty-two people completed the training in full (20 sessions). Three people completed 10-19 sessions and 5 people completed less than 10 sessions. The findings of this study indicated that if all 20 sessions were completed, there was statistically significant improvement in understanding rapid speech, and in listening to speech in noise. There was improvement in competing speech task; however, this was deemed to be due to procedural learning (Chisolm, et al., 2013). Overall, the report did find that LACE training does lead to perceptual learning.

Gil et al Study Results

The purpose of this study was to look at the efficacy of auditory training for elderly patients fitted with hearing aids, this was done using a randomised double-blind test. The participant pool consisted of 14 people aged 16-60, the hearing loss ranged from 32.3dB PTA right ear and 35.1dB left ear and they must be a current hearing aid user (de Miranda, Gil, & Iorio, 2008). The participants were split into 2 groups, a control group and an experiment group. Both groups were given baseline testing of pure tone audiometry, recognition of phrases in noise, non-sensitized speech recognition index test, speech test with white noise and hearing handicap inventory for the elderly. The auditory training group were evaluated 3 times before testing began. The formal hearing training was supplied in seven sessions held once a week with a duration of 50 minutes each, the training sessions were conducted from CD's, much of the training was targeted to either the left or right ear individually before the final session, which was binaural. This report found that the experimental group who received the auditory training had seen a statistically significant improvement form SRPI and SWW. The same results were also noted in speech recognition perceptive index. The experimental group also noted an improvement on the self-administered HHIE questionnaire, which indicated they have noticed an improvement in their ability (de Miranda, Gil, & Iorio, 2008).

Abrams et al Study Results

The objective of this paper was to determine if a remotely delivered auditory training program improved speech in noise understanding, and if the hours engaged

influenced the post intervention speech in noise test, this was completed using a randomised group control (Abrams, Bock, & Irey, 2015). Participants in this group were 30 adults aged from 46-77 years old with a hearing loss range of 25-70dB, all participants were fitted binaurally with Starkey hearing aids. The group were all fitted with the same hearing aids and given the same fitting and correction procedure, a baseline outcome measurement consisting of a HINT and WIN test was administered. The group receiving auditory training was then given access to the at home based RMQ training program. The participants were required to use RMQ for 30 minutes each day for 5 days for a 3-week period, whilst completing a self-reported log. During the period, both the control and auditory training group were given phone calls check-ups to ensure compliance. The results obtained from the HINT outcomes when compared at the end of the auditory training period did not show any significant difference between the control group. This was the same result seen when the WIN test was completed. These results lead the study to show that there appeared to be no improvements that were statistically significant between the control group and the auditory training group which completed the RMQ training sessions (Abrams, Bock, & Irey, 2015).

(See Table 2.)

DISCUSSION

This literature review has been created to look at and understand if auditory training should be used in a clinical environment to help underpin hearing aid user's rehabilitation process. To see if it will increase their understanding of speech in noise, and if the hearing aid user felt that their ability to hear and understand had been improved, through the training.

Through the literature, different approaches have been used to apply auditory training principles to their participants. This has led to a variety of different results between the papers. However, looking at the articles it can be broken into face to face training and computer-based training methods. With the improvement in technology and computer savvy adults, the ability for the participants to conduct their training at home has positive and negative implications. As noted in the study by Abrams, Bock and Irey (2015), the participants ability to navigate the website and technology required for the study could have had a negative impact on the results. All of the computer-based studies did provide over the phone technical support and testing of hardware and software; however, this may not have been enough for some of the participants, and it was not explored as a factor of negative results in the studies (Chisolm, et al., 2013; Henshaw & Ferguson, 2013). Another limitation to computer based at home auditory training is the amount of time dedicated to learning. It was seen in two of the studies that not all participants met the required at home learning targets, the studies do not specify why the participants did not complete the training programs or did not meet the study objectives. This being stated, 2 out of the 3 studies indicated positive results from their auditory training programs in the outcome measures, when the training is completed in full.

The outcome measures with computer based auditory training programs in the literature reviewed were all based off different program lengths and used a variety of different outcome measures. In the studies

that did see improvements, they were in different stages of the training cycle, in the study by Chisolm, et al., (2013), the main improvements were seen in sessions 5 & 10 out of the 20 sessions in the program. The study by Henshaw & Ferguson (2013), also showed improvements; however, theirs were noted over the progression of the training program. The result observed in these studies support findings found in historical literature on auditory training. The Abrams, Bock and Irey (2015) study did not indicate any improvement from the internet based auditory training program provided; however, the researchers felt this could have been due to the compliance from the participants, noting that the auditory training group only indicated 4.5 hours of training per week instead of the required 7.5 hours per week. This could have had a direct correlation to the results from the trial. This being stated, the overall results were positive from the literature showing improvement by the participants when hearing aids were fitted and auditory training was provided as a rehabilitation process.

Face to face auditory training was used in two of the studies reviewed, this does require a more hands on delivery process compared to computer-based learning and could have a financial implication on a clinic long term. However, it is important to understand if there is an added benefit from this approach. Both programs were delivered face to face to new hearing aid users, the delivery of the auditory training was different, and the outcome measures were also different. The study by de Miranda, Gil, & Iorio (2008), showed positive results from auditory trianing and hearing aid wearing for elderly adults. There was a significant improvement in the outcome measures and self-reported questionaires showed that the people who participated in the auditory training programed noticed an improvement in their auditory perception compaired to the control group, who did not notice any significant change after 12 weeks of hearing aid useage. This indicated that the participants did not feel that their hearing loss was an issue when socialising. This led the researchers to the development that hearing aid fitting alone is not the only way to help a person hear but formal hearing training is the best way to achieve positive results (de Miranda, Gil, & Iorio, 2008). This result is not necessarily the same result observed in the study by Nkyekyer, Meyer, Pipingas, & Reed (2019). They did note that the use of hearing aids contributed to a decrease in depression and also improved speech perception; however, there was no evidence to indicate that the partipants were able to track speech better with or without hearing aids. The study also indicated that there was no significant difference between hearing aid users before or after the auditory training program. The researchers indicated that this could have been due to the fact that all partipants were new hearing aid users and the researchers were unable to track the amount of hearing aid usage time per day.

The literature reviewed was from a variety of different study designs, this included, cross-over pilot, controlled trails, repeated measures. Three of the studies used randomised controlled trials, providing a high level of evidence. Of all the studies used, only one used a double blinded test (de Miranda, Gil, & Iorio, 2008), which provides a strong amount of evidence. The participation numbers in the study did vary from 14 to 50 adults. With a variety of program intervention, timeframes from 6 weeks to 7 months, long term result follow ups of the studies were not reported to see if

any improvements were seen during period after the training program was discontinued. Self-motivation of the participants using at home computer based training program could also be a contributing factor on how the group performed overall (Abrams, Bock, & Irey, 2015).

Consistency across all the literature reviewed is a weakness of the current review. With the varied study approaches taken; study design, participation numbers and requirements, outcome measures, auditory training delivery and reporting protocols, by the studies it is difficult to understand if significant improvements were made by the participants or if there is a level of bias in the results. As the biggest study only had 50 participants (Chisolm, et al., 2013), it is difficult to see if the processes implemented for the papers could be applied over a larger number of participants and still achieve the desired results. Further research with larger trials would be beneficial to see if results can be replicated, whilst also trying to determine the best timeframe for the training programs, so they are not too long to keep engagement, but not too short and miss out on achieving the desired results.

The future direction for auditory training appears to be computer-based. With the increase in technology, affordability and the average person's technical ability to use them effectively, a self-paced, user-friendly auditory training program could be beneficial for clinics, to increase hearing aid satisfaction, and incorporate auditory training into their current rehabilitation processes. This would help overcome the current issues facing clinics of the cost-time benefit of auditory training programs (Brouns, El Refaie, & Pryce, 2011). That being stated, the evidence of current literature shows that compliance is key for good results. When programs are completed at home, there is always the potential that the training is not completed properly or is not completed at all. This could mean a more inclusive approach may be needed with regular communication between clinics and participants; however, more research would be needed in this area.

CONCLUSION

This current review of literature has found that there is promise in auditory training for hearing aid users. The effectiveness of the training and the best means of application still need to have further research. The best way forward would appear to be a computer-based package that can be supplied to participants that are fitted with hearing aids to try and improve their speech perception in a wholistic approach to hearing aid rehabilitation. Current hearing aid rehabilitation plans used in clinics already provide a basis for growth in this area.

The literature showed that participants in the auditory training program used their hearing aids more than the control groups (Abrams, Bock, & Irey, 2015). This may indicate that the participants acclimatised to their hearing aids more efficiently, which would be another benefit for clinical use. The research in the area of auditory training does have some weakness, with a variety of approaches, different outcome measures and small participation numbers it is difficult to evaluate how this can be executed in a clinical practice. The long-term benefits of the programs were also not shown, to see if the improvements indicated (if any at all) in the auditory training program last or if after the training was completed that the

participants skills slowly decreased. A more targeted research study would be beneficial to understand if clinical implementation should be considered, and if it is cost-time effective for clinics to implement into their current rehabilitation program. Whilst the current research is mixed in its success, there is some benefit shown in speech recognition scores; however, it is difficult to definitively say that auditory training improves speech discrimination for hearing aid users.

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APPENDIX

Table 1.

Study Quality

Article	Study Type	Participants Drop/out	Outcome Measures Specified	Ethics Policy
Nkyekyer et al., 2009;	Randomised Cross-over pilot study	No Dropouts noted	Yes	Yes
Henshaw et al., 2013;	Repeated measure design.	Not Specified	Yes	Not Specified
Chisolm et al., 2013;	Randomized controlled trail	Yes	Yes	Not Specified
Gill et al., 2008;	Randomised double blinded test	Yes	Yes	Yes
Abrams et al., 2015;	Randomized groups Control	Not Specified	Yes	Yes

Table 2.

Summary of case study results

Article	Nkyekyer et al., 2019;	Henshaw et al., 2013;	Chisolm et al., 2013;	Gill et al., 2008;	Abrams et al., 2015;
Study Type	Randomised Cross-over pilot study	Repeated measure design.	Randomized controlled trail	Randomised double blinded test	Randomized groups Control
Participants Details	Participants: 40 Ages: 50-90 Hearing Loss: range 25-70dB	Participants: 30 Ages: 50-74 Hearing Loss: range 21-69dB	Participants: 50 Ages: 58-85 Hearing Loss: range right ear mean: 46.0dB left ear: mean 47.6dB	Participants: 14 Ages: 16-60 Hearing Loss: range right ear mean: 32.3dB left ear: mean 35.1dB	Participants: 30 Ages: 46-77 Hearing Loss: range 26-70dB
Outcome Measures	APHAB SPT	Speech in noise Self-reported listening Working memory performance	WIN NU No.6 Modified NU-20 Competing message test WAIS-III R-SPIN	SRPN SRI with recording STWN HHIE	HINT WIN
Training Used	Weekly face to face AT sessions of continuous discourse speech tracking. Each training session went for 15 minutes and went for 6 months.	Instructions and 2 initials of phoneme-discrimination-in-noise training. Training is at home for 30mins a day (2x 15min sessions) for 7 consecutive days. Training was delivered on Computer	Complete 1 LACE session daily for 5 days per week until 20 units are completed	Training was given in clinic in 8; 1-hour training sessions held twice a week for 4 weeks	Control group was given normal hearing fitting procedures. Auditory training group was given RMQ via the internet on computers 5 days a week for 3 weeks 30 minutes per session
Results	There was significant change in SPT results after training when combined with hearing aid usage.	Results showed significant improvement in phoneme-discrimination-in-noise threshold over time. No significant improvements for 3 out of 4 trained phonemes with poorest initial thresholds	When all LACE sessions were completed there where statistical significants in speech in noise testing	After FHT significant improvements in the results were obtained in SRPI and SWWN	Using WIN and HINT outcomes measures there was no significant difference from RMQ training to control group