AUDITORY TRAINING PROGRAM FOR INDIVIDUALS WITH POST-LINGUAL HEARING IMPAIRMENT: A SCOPING REVIEW

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ABSTRACT

Introduction: Auditory training (AT) is an important area in aural rehabilitation that benefits individuals with post-lingual hearing impairment using amplification devices. The main benefit in targeting the auditory training program is to increase the quality of life by holistically reducing the hearing-loss-induced deficits of function through a combination of sensory management, instruction, perceptual training, and counselling. It also stimulates a successful listening using a training stimulus that engage the process for the role of cognition in auditory training, specifically executive processes such as attention switching and updating of memory. Such approach will need a meaningful training program for users to be able to generalize them in everyday life. This study is aimed at reviewing auditory training program in literatures for individuals with post-lingual hearing impairment with respect to the ***designs*** and ***parameters*****. Methods:** Pubmed, Science Direct, Scopus and Pro Quest (medical and health) databases were searched using English keywords; *hearing loss, auditory training, hearing aids, cochlear implants, perceptual learning, aural rehabilitation, auditory rehabilitation, adult*. Papers were selected from year 2013 to 2018 and papers from grey search were included if the paper has been quoted as important to learn further about AT program used in paper accepted from databases. 209 papers were identified from the databases. After removing duplications and screening of the inclusion criteria, a total of 24 papers were accepted; 21 papers from databases search and three papers from grey search. All selected papers were reviewed by four reviewers. This study adopted Preferred Reporting Items for Systematic Reviews and Meta-analysis extension for Scoping Review (PRISMA-ScR). **Results:** The results described 15 auditory training programs from 24 papers with each program has an exceptional ***design*** but shared practically the same ***parameters***. The AT program ***designs*** includes; 1. sample size, 2. hearing status, 3. hearing devices, 4. hearing age, 5. measurement test, 6. training sequence, 7. training durations, 8. training frequency, 9. length of training, 10. location of training, 11. training delivery style; either computer based or face to face, with trainer or self-training and individual or group training, 12. findings and 13. retention effects. The ***parameters*** used in auditory training program contains; 1. training activities, 2. training theme, 3. communication strategies, 4. methods, 5. approaches, 6. mode, 7. auditory skills, 8. speech stimulus, 9. sound stimulus and 10. complexity of training. **Conclusions:** Auditory training program for individuals with post-lingual hearing impairment was described in specific designs? and parameters to achieve its goal. The finding of this study could be used as a general guideline to develop the content and structure of future auditory training program.

KEYWORDS: Scoping review, auditory training, adult hearing loss, post-lingual hearing impairment

INTRODUCTION

Post-lingual deafened or post-lingual hearing impairment was described by Lazard et al. (2014) as a deafness appears after language acquisition and stabilization, the sensitive period of maximal plasticity has elapsed and major brain specializations are fixed. Researchers such as Hughes et al. (2018), Lin et al. (2013) and Strawbridge et al. (2000) emphasis on the alarming sequalae of sensory neural hearing loss (SNHL) among post-lingual person that might include cognitive impairment and dementia. While Turunen-Taheri et al. (2019) stated that SNHL leads to brain atrophy and neuroplasticity that may be detrimental to auditory rehabilitation and believed that the use of hearing aids may slow or improve this pathology. Therefore, the individuals with post-lingual hearing impairment require a reorganization of their current listening capabilities. This reorganization enables them to maintain their social habits without changing their communication mode to sign language which involves adapting to their hearing handicap, which is constrained by both anatomical and functional factors (Lazard et al., 2014). Blamey & Alcantara (1994) explained that a person with post-lingual hearing impairment may need auditory training with specific aims to minimize the hearing impairment consequences.

Auditory training (AT) is an important area in aural rehabilitation for post-lingual hearing-impaired person. Sommers (2016) and Beier et al., (2015) pointed out that auditory training is a strong ally for the auditory rehabilitation which benefits the hearing impaired individuals with amplification devices. They stressed that the comprehensive aural rehabilitation program will have better potential benefit when auditory training is included in the program. The two main benefits of the auditory training program are; 1. to improve users' participation in daily activities and 2. to increase the quality of life by holistically reduce the hearing-loss-induced deficits of function through a combination of sensory management, instruction, perceptual training, and counselling (Boothroyd, 2007). These two objectives aim to create effective listening conditions for hearing-impaired adults by utilizing a training stimulus proposed by Ferguson and Henshaw (2015). This training stimulus is designed to engage cognitive

processes, particularly executive functions such as attention switching and memory updating, underscoring the fundamental role of cognition in auditory training. The resulting AT module should constitute a meaningful auditory training program that users can apply in their daily lives. Hence, the development of an AT program should address the user experience improvement in everyday communication skills to illustrate the effectiveness of the AT program (Sweetow and Sabes, 2010).

Many hearing care professionals believe that auditory training cannot be fit into their routine clinical protocols because they believe that it is too expensive and time-consuming (Tye-Murray, 2016). This scoping review aimed to examine the AT programs that are available in literatures to find the best AT program protocol that may minimize the time-consuming and monetary issues in delivering AT. The scoping review will be visualizing the AT program content that is efficient and also that can be fit into the routine clinical protocols.

The Need of Scoping Review to Produce an Auditory Training Program Design

A scoping review is a mean for examining the trends in currently available AT programs, as recommended by Tye-Murray (2016). The aim is to provide audiologists and hearing care professionals with new strategies to achieve the goals for delivering a good quality hearing healthcare.

Valente (2015) recommended guidelines for the audiologic management of adult hearing impairment by, which emphasize the importance of understanding patients' specific communication needs and setting realistic expectations for interventions. The need for this scoping review is to create an AT program **design** that adheres to Valente's recommendations, primarily because there is currently no universally recognized gold standard for AT programs documented in the literature. The AT program design will cover factors such as program duration, frequency, length, location (computer-based or face-to-face), and involve a trainer or self-training as well as to be conducted individually or in groups. The design will also serve as a guide for audiologists and hearing care professionals to conduct future AT programs that it is tailored to patients' specific needs to measure the benefits of amplification outcomes accurately.

The outcomes for precise measurements of treatment are crucial for developing evidence-based clinical practice guidelines. However, as noted by Zhang et al. (2014), the provision of auditory training and the choice of training type (e.g.: computer-based or face-to-face) should be individualized. In a systematic review on the impacts of aural rehabilitation on the quality of life among older adults, Michaud and Duchesne (2017) found that no overarching trends emerged in the study due to the limited clinical applicability of the results. They found out that their systematic review findings were inconclusive because the assessment tools used to measure AT progress were lack of sensitivity and the reported interventions for adult hearing impairment lacking complete validity markers, leading to a risk of bias. The scoping review will provides recommendations for the guidelines for an AT program design and to raise awareness among trainees and trainers on the importance of conducting AT programs for individuals with post-lingual hearing impairment. Subsequently, it will also emphasize on the need for an updated AT program design to help both trainees and trainers in achieving the maximum benefit from AT programs.

Cardemil et al. (2014) have indicated that the use of hearing aids and individualized communication programs in adults as interventions can positively improve listening abilities? and speech perception. The AT programs, as part of auditory rehabilitation strategies, also have potentials to enhance the quality of life (Cardemil et al., 2014). This underscores the necessity for a scoping review to describe a comprehensive and practical auditory training program design for hearing healthcare professionals and patients. This scoping review is essential to gather evidences regarding the effectiveness of auditory training programs, specifically in assessing the variables outlined in the expected AT program design. It intends to create a structured AT program that can be assessed and audited externally to prevent assessment bias. The goal of this research is to produce a set of AT program designs. Based on these designs, an auditory training program should allow users to utilise informed choices by discussing their strengths and areas for auditory skill improvement with a clinician. This approach is expected to have a high impact and convenient to? both providers and recipients of hearing healthcare services.

The Need to Do Scoping Review on The Parameters That Defined an Effective Auditory Training Program

The AT program **parameters** explain the methods, approaches, modes, auditory skills, speech stimulus, sound stimulus and complexity of training used for individuals with post-lingual hearing impairment.

However, at present, there are no established parameters for an AT program that can serve as a reference for the development of such a program. For example, the current research review trend was focusing on auditory training program efficacy and benefits on a very specific areas or explain only prominent area. Michaud and Duchesne (2017) reviewed the effects of aural rehabilitation on quality of life in an older adult population, Beier et al. (2015) reviewed on auditory training benefits, Lawrence et al. (2018) reviewed the efficacy of auditory training on cognition, Henshaw and Ferguson (2013) reviewed on efficacy of auditory training on speech intelligibility, cognition and communication abilities and R. Sweetow and Palmer (2005) reviewed on efficacy of auditory training on communication skills. Therefore, this scoping review intended to compile all parameters used in the previous AT programs that may benefit for producing a new AT program.

According to Clark et al. (2008), Boothroyd (2007) and Hull (2014), audiologic management for hearing-impaired adult has a huge area that need to be included in the intervention such as, sensory management, auditory training, counselling. The auditory training itself also has various training components that may be administered on patient based on their needs. While Sommers (2016) stated that an individual auditory training at home on tablet-based devices with game-like formats will dramatically improve the ease and flexibility of administering auditory training and maintain the training over extended periods of time. However, the training gains could not be generalized outside the training materials. Sommers (2016) again stated that auditory training might be most effective if it is done using the voice of a specific individual who the trainee wants to understand, such as a spouse or a teacher. This dilemma showed the importance to compile all parameters in auditory training program to be acted as a guideline to produce a comprehensive auditory training program.

Each parameter in auditory training programs will be documented to understand the mechanism of the auditory training. This study will get a clear idea regarding the structures used in most auditory training programs available because auditory training program has wide area to target. The information gathered in this scoping review is hoped to explain the AT parameters available in the literatures to develop an AT program. Therefore, this study is essential to help both trainer (hearing health care) and trainee (patients or subjects) to achieve any specific goals in AT program.

The main objective is to review auditory training program available in literatures. While the specific objectives are; 1. to identify the auditory training **design** (durations, frequency, length, location, computer based/face to face, with trainer/self-training, individual/group) used in the individuals with post-lingual hearing impairment auditory training programs? and 2. to identify the auditory training program **parameters** (methods, approaches, modes, auditory skills, speech stimulus, sound stimulus and complexity of training) used in the individuals with post-lingual hearing impairment auditory training programs.

METHODOLOGY

The scoping review study was drafted using the Preferred Reporting Items for Systematic Reviews and Meta-analysis extension for Scoping Review (PRISMA-ScR) by Tricco et al. (2018). In this research, audiologists and hearing healthcare professionals who perform auditory training will be recognized as 'trainer' whilst the person with post-lingual hearing impairment will be known as 'trainee'.

Eligibility criteria

The eligibility criteria to accept or reject paper in this research are derived from suggestion made by Moher et al. (2009) to use PICOS; with reference to 1. **P**articipants; adults aged above 18 years old (based on definition of adult given by WHO (2010), with any degree of hearing loss using hearing aid(s) and/or cochlear implant(s) and/or any listening device(s) and also a normal hearing subject uses hearing impaired simulation device. 2. **I**nterventions; Interventions included in this study are all auditory training program available in English or Malay. To exclude program which has no publication to validate the scientific merit, to exclude paper with no intervention for auditory training program (e.g., paper with general information about auditory training program only) and also to excludes review-only paper. 3. **C**omparisons; Comparison with a control group or repeated measures (pre and post training comparison). However, if the paper has significant relation with this scoping review, it will be accepted and recognize under 'grey search'. 4. **O**utcomes; Outcomes measures related to listening skills, speech intelligibility, cognition and communication (either behavioural measures or self-reported outcomes) will be included in this studyand 5. **S**tudy design of a paper**;** The study designs accepted are

randomized controlled trials, nonrandomized controlled trials, cohort studies, repeated measures studies (pre and post training comparisons), case studies, reliability test and validity test.

Selection of paper

The paper search was done through four databases; **Pubmed, Science Direct, Scopus, Pro Quest (medical & health)**. Only papers from year **2007 to 2017** have been included in this study. **Grey Search papers** has also been included since it has significant relation to the papers accepted from databases. For example, the grey search paper was quoted from accepted paper as important to learn further about AT program.

The keywords used for database search include the *hearing loss, auditory training, hearing aids, cochlear implants, perceptual learning, aural rehabilitation, auditory rehabilitation, and adults*. They were selected based on the objectives and literature review of adult auditory training program.

The selection of sources of evidence has been done by a team consist of one speech-language pathologist (Reviewer 1, the main author), one audiologist with Ph.D. (Reviewer 2, second author), one audiologist (Reviewer 3) and one undergraduate audiology student (Reviewer 4). The decision whether to accept or remove a paper was under the prerogative of the reviewers through discussions and meetings.

All the articles were processed in three phases. The first phase is the identification process whereby all paper's titles were screened and identified using searched keywords from all databases (*hearing loss, auditory training, hearing aids, cochlear implants, perceptual learning, aural rehabilitation, auditory rehabilitation, adults*). Accordingly, the title of the papers were screened for any duplications. During this phase, 209 papers were identified, and 10 duplicates were removed.

During the second phase, 199 Abstracts of the papers were screened by the reviewer 1 and 3. Both of the reviewers then agreed to removed 154 papers as the papers did not meet with eligible criteria of this study. Therefore, a total of 45 papers were further reviewed in the next phase.

The third phase was done by Reviewer 1 and 2 on 45 selected papers. In this phase, a full-text screening was done and both reviewers decided to exclude 24 papers from 45 selected paper and to include another three papers from grey search. These three papers were included because the documents were referred for final selection to explain the auditory training program used in their research. Finally, a total of 24 papers were included in this study. The selection process is shown in figure 1.

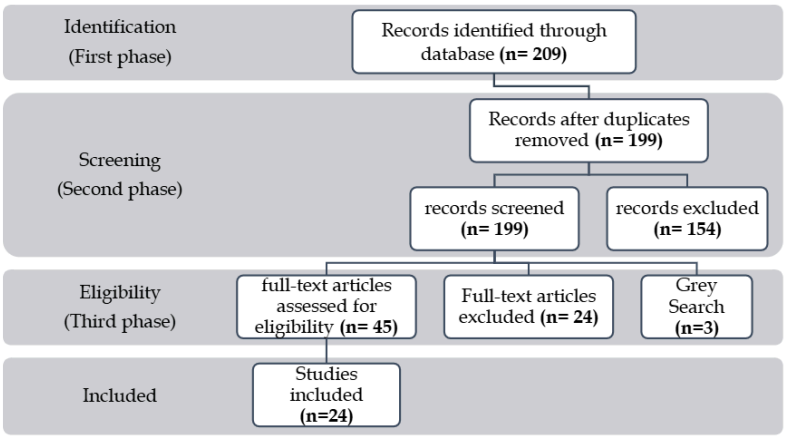

Figure 1 The Findings of Papers Searching

Data charting

The data charting process uses thematic analysis process by Braun & Clarke (2006) which was further explained in Maguire & Delahunt (2017) to induce the content of auditory training program. The process of determining the themes involved six steps; 1. Familiarizing with data, 2. Generating initial codes, 3. Searching for themes, 4. Reviewing themes, 5. Finalizing themes and 6. Defining themes.

All 24 papers have been given identity number (ID) from ID01 to ID24 to be recognized distinctively. From 24 papers, 15 auditory training programs has been identified. Some papers were using the same AT program, hence only 15 AT program from 24 papers. Each of the program has been given another ID to be explained and recognized. The ID is uniquely distinctive from paper ID, which identifiable from P01 to P15 (P is stand for program).

The data charting process were shown in Figure 2. Panels in the team who did full-text review were Reviewer 1 (the main author), Reviewer 3 and Reviewer 4. The reviewers read and re-read all papers to get a clear notion about the entire body of data as suggested by Maguire and Delahunt (2017). If the reviewers found any unfamiliar corpus, a consultation from related professional to better understand the paper was conducted. The consultation is to familiarize with any terms and concepts introduced in the paper to fathom the key ideas. data including bibliographical information, aims and results from the 24 papers were reviewed and extracted independently by all the reviewers. The key ideas known as code has been identified and themes has been generated. The team checked the data and had several meetings to find agreement on the findings. Early impressions and immediate thoughts were recorded to form an initial framework for further process.

Generating initial codes is the first stage by organising the coding process in a meaningful and systematic way using the ***main category***. The main category is formed from the research questions and familiarization process. Initially, team has construed three main categories using theoretical thematic analysis (Maguire & Delahunt, 2017). The initial categories were suggested based on objectives and abstract screening. They are; 1. Research background, 2. Auditory training program and 3. Outcomes measurements. The main category will serve as an outline to generate preliminary ideas about codes in full-text review. The category was tested for applicability in all 24 papers where the researcher generates codes from every segment of text that seemed to be relevant to specifically address the research question (Maguire & Delahunt, 2017).

Based on these three categories, a potential code has been derived; an outline to further induced codes from papers. In this stage, even though the category has been set, the reviewers used open coding process. The codes searching is not solely bound to the category, but it will also not astray away from the category. These two ways are to outline a strategic searching system to achieve goals. The codes were compared, discussed and modified one by one, moving from one paper to another. The process has been done by hand, working through hard and soft copies of the papers using pens and highlighters.

A theme is characterised by its significance with the codes and definitions (Braun & Clarke, 2006). The preliminary themes were identified from the initial codes. The reviewers examined the codes and found a clear fit together codes into a theme. Further reviewing the codes, the team agreed to refine the category and formed them into two main categories; 1. Auditory Training Program Design and 2. Auditory Training Program Parameters

All initial themes derived were reviewed, modified and associated with each theme in all 24 papers. The team considered whether the data really did work in the context of the entire data set (Maguire & Delahunt, 2017) then the theme have been accepted. However, four conditions may happen during this process; 1. The themes do not make sense, 2. The data does not support the themes, 3. The themes overlap, 4. Themes within themes. For each condition, the researcher has to enlist three action to treat the data. The decision either to remove, put in other related themes or to form new theme. All of this decision based on discussion among team members.

All 251 codes were translated into themes and sub-themes by thorough and comprehensive review across all 24 papers. Themes were checked against each other and backed by the data of the original papers to be harmonised with key ideas. In the process, the theme has undergone a treatment if they experienced the four conditions, 1. The themes do not make sense, 2. The data does not support the themes, 3. The themes overlap and 4. Themes within themes. The treatment was 1. To remove the

themes, 2. To move to any other related themes and 3. To form new themes or sub themes. This process is to produce a coherent, consistent and distinctive themes (Cruzes & Dybå, 2011).

Final themes were compared across all papers and interpreted into a model of two higher-order themes; 1. Auditory training program design and 2. Auditory training program parameters. The model of higher-order themes has 23 themes and 77 sub-themes. They were checked against research question and found to be able to describe themes relationship clearly.

This is the final refinement of the themes which aiming to identify the essence of what each theme is about (Braun & Clarke, 2006). The team's panel has to analyse the themes with each of the themes has been given a name and definition. Definition of each name was based on description appeared in dictionary, description suggested in literature (all references were stated) and a newly developed name which fits themes described in the papers. The definition which was accepted should be appeared and harmonised with the key concepts presented in the papers.

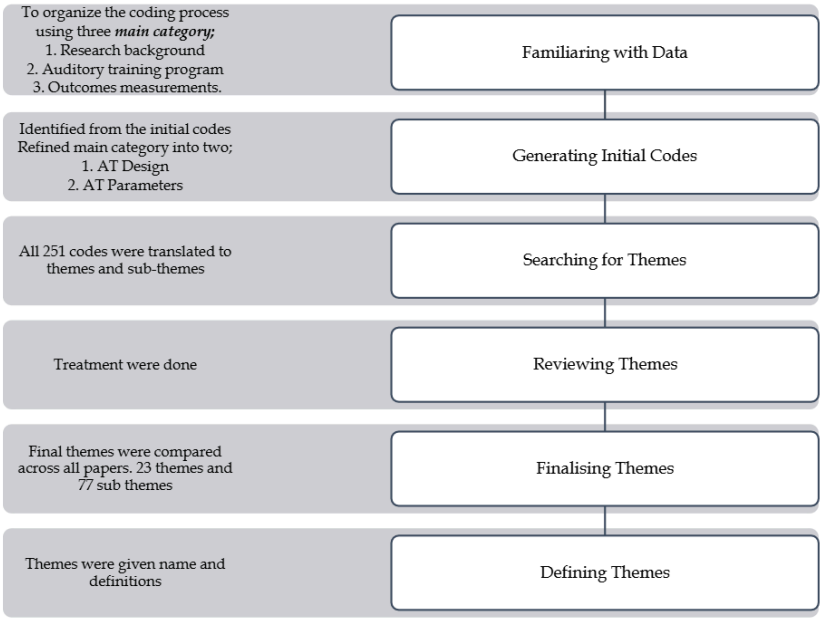

Figure 2 Data Charting Process

RESULTS

Results of Auditory Training Design (N=24)

The auditory training designs of selected studies are presented in table 1. The auditory training designs are including the; 1. author(s) and year of the paper published, 2. total sample Size (N) that indicate the number of subjects included in the research, (i.e.: the total number of participants in training and control group, 3. hearing status showing hearing devices used and hearing age, 4. auditory training name or description (if the program was not given a specific name), 5. measurement test used in the research, 6. research sequence and procedure 7. training duration and frequency, 8. training location (either at home or in laboratory), 9. auditory training delivery style (either computer based, with trainer, individual or in group, 10. findings of the papers (either positive findings; when the results showed better performances with AT program and negative findings; when the results showed regression findings, no differences findings, or findings which are not available) and 11. retention effect, if available. In this part, each of all 24 papers has been identified based on the ID number.

In general, studies on auditory training show large variation in terms of sample size (between n= 2 to n=279). However, 75% (18 out of 24 studies) of the study utilized sample size less than 100 participants

(< 100 participants). Studies that used large sample size (> 100) normally governed to the efficacy using self-training computer-based with audiologist as supervisor as shown in a several numbers of studies including, ID01, ID06, ID10, ID11 and ID23.

On the study compliance, 83% (20 out of 24 studies) of the study showed 100% compliance rate where all subjects recruited at the beginning had completed the whole research process. The lowest compliance rate recorded is in study ID 14 with 22 subjects complied from 49 subjects recruited because most of the subjects did not meet the inclusion criteria of the study.

13 out of 24 papers (54%) in this review have compared the improvement of the AT program between groups; a training group and a control group with 8 papers have 1:1 ratio of subjects in both groups (similar number of participants in the training and the control groups). The other 5 papers have training have higher number of participants in the training group than in the control group. 11 papers have not compared their research with control group.

71% of the study in this research used subjects with hearing loss (17 out of 24 papers) and another seven (29%) research used normal hearing subjects. The hearing loss range was mostly mild to moderate hearing loss subjects. Least papers (14 out of 24 studies) used severe to profound hearing loss subjects because most papers in this review were investigated hearing aids user.

Regarding hearing age, 58% of the study (14 out of 24 studies) did not specify the hearing age. The studies that showed hearing age were randomly from one month to 44 years.

In this review, three types of measurement have been used; standardized test, newly developed test or combination of these two types of measurement. The standardized tests were administered to measure either speech-perception, hearing handicap-perception or cognitive-performance. While the newly developed test was done to measure the specific area trained in the programs, for example The build-a-sentence Test developed in Customized Learning Exercise for Aural Rehabilitation (clEAR) by Tye-Murray et.al. (2008).

Research sequence and procedure is to show how the research and training has been conducted in each studies. Nine models of procedure were found in 24 papers; 1. PTP (pre-training, training, post-training), 2. PTPP (pre-training, training, post-training 1, post-training 2), 3. PPTPP (pre-training test 1, pre-training test 2, training, post-training 1, post-training 2), 4. PPTP (pre-training test 1, pre-training test 2, training, post-training test), 5. PTMP (pre-training test, training, mid-training test, post-training test), 6. PTMPP (pre-training test, training, mid-training test, post-training test 1, post-training test 2), 7. PPTMPP (pre-training test 1, pre-training test 2, training, mid-training test, post-training test 1, post-training test 2), 8. FPTP (familiarization, pre-training test, training, post-training test), and 9. FPTPG (familiarization, pre-training test, training, post-training test, generalization).

Pre-training and post-training measured the same outcome measures and tested according to the research's sequence and procedure. Training part was given to all subjects if the research has no objectives to compare between training and control group. The process of familiarization and generalization is to get the subjects to be familiar with training content or to use the training content in everyday life. Based on this review, 33% of studies used PTP sequence in their study (eight out of 24).

Each AT was design to be in a specific time duration per session, with specific frequency of training and in stipulated length of time. 33% studies (8 out of 24 studies) conducted training less than $\leqslant$30 min and 31 to 60 min per session with 38% of studies (9 out of 24 studies) were conducted between 10 and 20 session in $\leqslant$4 weeks.

This review found out that 63% of studies (15 out of 24 studies) were done in laboratories as compared to homes. While training delivery style explained AT either in computer based, face-to-face (F2F), with trainer, self-training (ST) individual or group showed 13 programs are computer- based program with only two program used face-to-face program. The programs were mostly focused on speech-perception training which 11 programs trained in speech, two programs trained in musical perception and one in environmental sounds. Only one program trained in cognitive-perception. Based on this review, 70% of the training (17 out of 24) were self-training and 79% of the studies (19 out of 24 studies) were done individually

Research findings in each paper has been classified either positive findings, no differences findings or findings which is not available. Positive findings are when the training has showed a significant better

training effect. 67% of the studies showed positive findings for their training (16 out of 24 studies). However, seven papers found no differences between pre and post training.

The retention effect is to see if the training is remained as a post-training. Only ten papers studied the retention effect which eight paper showed retention effect and two paper showed no retention effects. A total of 12 papers did not carry out research on retention effect and two are still on-going. Therefore, the result was not available.

Table 1 Descriptive Summary Of The Auditory Training Design

ID	Author and year	Sample Size		Hearing Status			AT Name or Description	Measurement Test	Research Sequence/ procedure	Duration, frequency and length of training	Location Home (H) Laboratory (L) Auditory Training Delivery Style Computer based/ Face-to-face/ with trainer/ self-training (ST) individual / group)	Findings + (positive, ND (No differences), NA (Not Available)	Retention
		Total (N) Total subject complies	Training group Control group	Hearing Status	Hearing Devices	Hearing Age							
1	Saunders et al. (2016)	243 243	206 73	Mild to Mod	HA	. 4wk to 6mo . ⩾6mo	Listening & Communication Enhancement (LACE)	**Standardized test** Word-in-Noise-test (WIN) (Wilson et al. 2003; Wilson & McArdle 2007) NU-6-word lists (Wilson et al. 1994) Modified NU-20 test (Olsen & Carhat, 1967) Wechsler Adult Intelligence scale 3rd Edition, WAIS-III (Wechsler, 1997) The Low Predictability Sentences performance on the multi-SNR R-SPIN (Wilson et al. 2012) Abbreviated Profile of Hearing Aid Performance (APHAP) (The; Cox & Alexander 1995) Hearing Handicap Inventory (HHI) for the elderly and adults (Ventry & Weinstein 1982; Newman et al. 1990)	Pre-training test 1: Inclusion assessment Pre-training test 2: Baseline (within 6wk of pre-test 1) Training: 2wk to 4wk Post-training test 1: Immediate post training: Within 2wk of the end of the training period. Post-training test 2: 6mo post training: occurred 6mo to 8mo following	30 min 10-20 sessions 2wk to 4wk	H Computer based ST Individual	ND	No 6mo

2.	Tye-Murray et al., 2017)	47 47	47 0	HL (NS)	HA	NS	Customized Learning: Exercises for Aural Rehabilitation (clEAR) formerly known as: I Hear What You Mean	**Standardized test** Transfer-Appropriate Processing (TAP) style measure of improvement (Barcroft et. al., 2011b, 2016) The Build-a-Sentence test (BAS) (Tye-Murray et al., 2008)	Pre-training test Training: • The spaced group; began training within 1wk of completing the Pre-test, • The massed group; started at the 8th wk Post-training test 1 Post-training test 2: 3mo after the post-training test 1	60 min 20 sessions 5th wk and 10th wk	L Computer based ST Individual	ND	Yes 3mo
3.	Rishiq et al. (2016)	24 24	12 12	Mild to Mod	HA	NS	ReadMyQuips (RMQ)	**Standardized test** The Multimodal Lexical Sentence Test for Adults (MLST-A) (Kirk et al., 2012)	Pre-training test 1: on the day of hearing aid fitting Pre-training test 2: after 4wk of hearing aid use prior to RMQ training Training or no training: 4wk Post-training test 2: after 4wk of RMQ training or no training	30 min 20 sessions 1 to 4wk	L: 1wk (first) H: 3wk Computer based T: 1wk ST: 3wk Individual	ND	No 4wk
4.	Preminger & Ziegler (2008)	50 47	>16 ⩾16	HL (NS)	HA	⩾3m	Audiologic Rehabilitation Classes	**Standardized test** City University of New York (CUNY) AB Isophonemic Word Lists (Boothroyd, 1984; Boothroyd, Hnath-Chisolm, Hanin, & Kishon-Rabin, 1988) CUNY Topic Related Sentences (Boothroyd et al., 1988) Hearing Handicap Inventory (HHI) for the elderly and adults (Ventry & Weinstein 1982; Newman et al. 1990) World Health Organization Disability Assessment Schedule II (WHODAS II) **Newly developed test** Class evaluation form: A subjective class evaluation form	Pre-training test: 2-wk prior first class Training or no training: 6wk Post-training test 1: 2-wk after training or no training Post-training test 2: 6mo after training or no training	60 to 90 min 6 sessions 6wk	L F2F Two trainers Group	ND	Yes 3m
5.	Shafiro (2008)	7 7	7 0	NH	None	NS	Environmental Sounds Training	**Newly developed test** Tested using the entire stimulus set (40 sound sources, 4 exemplars each, for a total of 160 stimuli)	Pre-training test Training Post-training test	30 min 5 sessions 2wk	L Computer based ST	+	NT

											Individual		
6.	Loebach et al. (2010)	144 144	96 48	NH	CI	NS	Speech Processed Training	**Newly developed test** Transcribe 20 spectrally degraded meaningful sentences	Familiarization Pre-training test Training Post-training test Generalization	NS	L Computer based ST Individual	+	NT
7.	Driscoll et al. (2009)	66 66	66 0	NH	CI	NS	Musical Instruments Training	**Newly developed test** Music Background Questionnaire (MBQ) Paired Associate Memory Test (PAT) Instrumental Simulation Recognition Test	Pre-training test: 1st wk Training: 5wk training Mid-training Test: 3rd wk of training Post-training test 1: 5th wk Post-training test 2: 7th wk	12 minutes 15 sessions 5wk	H Computer based ST Individual	+	Yes 7w
8.	Shafiro et al. (2015)	14 14	14 0	Mild	CI	⩾12m	Environmental Sound Training	**Standardized test** The Familiar Environmental Sound Test (FEST) (Shafiro, 2008; Shafiro et al., 2012) Consonant-Nucleus-Consonant (CNC), monosyllabic word recognition test (Peterson & Lehiste, 1962) Speech-in-Noise (SPIN-R) sentence test (Elliott, 1995)	Pre-training test 1 Pre-training test 2: (1wk interval from pre-test 1) Training: (4wk) Post-training test 1 Post-training test 2: (1wk after training)	40 to 60 min 8 sessions 1wk	H Computer based ST Individual	ND	Yes 1w
9.	Preminger & Meeks, (2010)	72 72	36 36	Mod	HA and CI	⩾3m	Audiologic Rehabilitation Classes	**Standardized test** Hearing Handicap Inventory (HHI) Elderly (Ventry and Weinstein, 1982) Modified HHI-Adult (Newman et al, 1990) Modified HHI-Spouse (Newman and Weinstein, 1988) 10-item Perceived Stress Scale (PSS) (Cohen and Williamson, 1988) Philadelphia Geriatric Center Positive and Negative Affect Rating Scale (Affect Rating Scale, or ARS) (Lawton et al, 1992) Communication in the Marriage Primary Communication Inventory (PCI) (Navran, 1967)	Pre-training test: 4wk before AR program Training: AR Class for 4wk Post-training test 1: within 2wk after completing AR program Post-training test 2: 6mo after training	90 min weekly	H F2F Trainer with and without spouse	ND	Yes 6m
10		240	240		HA	⩾3m		**Standardized test**	Pre-training test		L: 6 sites	NA	NA

	Miller et al. (2015)		0	Mild to mod			Speech Perception Assessment and Training System (SPATS)	The Win (word-in-Noise-test; Wilson & McArdle 2007) Quick Speech-in-Noise Test (Killian et. al, 2004) CID Monosyllabic Word Test in Quiet and in Noise (Hirsch et.al. 1952) Connected Speech Test (listen Only) (Cox et.al. 1987 and 1988) Connected Speech Test (Look and Listen) (Cox et.al. 1989) The abbreviated profile of hearing aid performance (APHAP) (Cox & Alexander 1995) **Newly developed test** Speech-Perception Tests (Speech Perception Assessment and Training System–Related)	Training: (30 hours) Post-training test 1 Post-training test 2: after 2-3mo post training	90 to 120 min 15 to 20 sessions	Computer based Trainer Individual		
11	Smith et al. (2016)	279 263	193 70	Mild to Mod	HA	. <6m . ≥6m	Listening & Communication Enhancement (LACE)	**Standardized test** Word-in-Noise-test (WIN) (Wilson et al. 2003) Hearing Handicap Inventory (HHI) for the elderly and adults (Ventry & Weinstein 1982; Newman et al. 1990) The abbreviated profile of hearing aid performance (APHAP) (Cox & Alexander 1995)	Pre-training test 1 Pre-training test 2: baseline Training: immediate after pre-test 2 Post-training test 1: immediate after training Post-training test 2: 6-month	30 min 10-20 sessions 2 to 4wk	H Computer based ST Individual	+	NA
12	Tyler et al. (2010)	12 12	6 6	Mild to Profound	CI	3y – 8y	Speech-in-noise and Localization Training	**Standardized test** Nucleus-consonant monosyllabic words (CNC) (Tillman and Carhart, 1966) CUNY sentences (Boothroyd et al, 1985) Hearing in Noise Test (HINT) sentences (Nilsson et al, 1994) Everyday sounds localization test (Dunn et al, 2005) **Newly developed** Real-world listening test for localization and recognition	Pre-training test: 38-96mo post-implantation Training: 1 to 3mo Post-training test	30min Frequency at own control 4 to 12wk	H Computer based ST Individual	+	Yes 7m
13		77	38		None	NS		**Standardized test**	Pre-training test	60min	H	+	NT

	Anderson et al. (2012)	77	39	Mild to profound			The Brain Fitness™ Cognitive Training	Quick Speech-in-Noise Test (Killian et al. 2004) **Newly developed test** Two subtests of the Woodcock–Johnson Tests of Cognitive Abilities The Integrated Visual and Auditory Continuous Performance Test Electrophysiology test	Training Post-training test	40 sessions 8wk	Computer based ST Individual		
14	Rao et al. (2017)	38	11	Mild to Mod	HA	4w	ReadMyQuips (RMQ)	**Standardized test** Cortical late event-related potentials (ERPs) Hearing in Noise Test (HINT) sentences (Nilsson et al, 1994)	Pre-training test Training (4 weeks) Post-training test	30min 20 sessions 4wk	L: 1wk H: 4wk Computer based T: 1wk ST: 3wk Individual	+	NT
		22	11										
15	Yu et al. (2017)	2	2	Mild to Mod	HA	NS	ReadMyQuips (RMQ)	**Standardized test** Multimodal Lexical Sentence Test for Adults (MLST-A; Kirk et al., 2012) **Newly developed test** Functional magnetic resonance imaging (fMRI)	Pre-training test Training: HA uses for 8wk and one subject receive 4wk training Post-training test	NS	L Computer based ST Individual	+	NT
		2	0										
16	Fu & Galvin (2007)	13	13	HL (NS)	CI	Several years	Computer-Assisted Speech Training (CAST)	**Standardized test** HINT sentence recognition thresholds in steady, speech-shaped noise IEEE21 sentence recognition in quiet **Newly developed test** Multitalker vowel recognition in quiet Multitalker consonant recognition in quiet	Passive learning: • Pre-training test (baseline): every 3mo • adaptation period: 18mo • Post-training test: Retesting every 2wk Active 1. Pre-training test (baseline): at least 2wk 2. Training: 1mo or longer 3. Post-training test: Retesting every 2wk	60min 20 sessions >4wk	H Computer based ST Individual	+	NT
		13	0										
17	Petersen et al. (2012)	24	15	Severe	CI+HA	NS	The Musical Ear-Training	**Newly developed test**		60min	H and L	+	NT

		24	9					Musical instrument identification (MII) Melodic contour identification (MCI) Pitch ranking (PR) Rhythmic discrimination (RD) Melodic discrimination (MD) The Hagerman speech perception test (HAG) An emotional prosody recognition test (EPR)	Pre-training test (baseline): within 14dy after CI switch-on Training or no training: 6mo Mid-training test: within 3mo training or no training Post-training test: after training or no training	24wk	Computer based and F2F ST and with Trainer Individual		
18	Wayne & Johnsrude (2012)	144 144	144 0	NH	None	NS	Perceptual Learning of Degraded Speech Training	**Newly developed test** Word-report task	Pre-training test Training Post-training test: testing (report) after each training item (given 25s for report after each sentence during both training and test)	NS	L Computer based Trainer Individual	ND	NT
19	Krull et al. (2012)	30 30	24 6	NH	CI or CI+HA	NS	Talker-identification Training	**Newly developed test** Sentence-recognition using two lists of sentences (in quiet and in noise) Emotion-recognition performance using 100 tokens in quiet	Pre-training test (first day) Training (4 days) or no training Post-training test 1 (at day 4) Post-training test 2 (after 30 days)	4 sessions 45 to 60min 4dy	L Computer based ST Individual	+	Yes 1m
20	Richie & Kewley-Port (2008)	14 14	7 7	NH	None	NS	Vowel identification Training	**Newly developed test** Closed-set vowel identification test (vowels in CVC context) An open-set monosyllable word recognition test An open-set sentence recognition test (Central Institute for the Deaf Everyday Sentences)	Pre-training test: First day. designed to assess the participants' untrained auditory–visual speech perception abilities Training: 6 sessions or no training Post-training test: final day of testing.	60min 6dy	L Computer based ST Individual	+	NT
21	Loebach et al. (2009)	48 48	24 24	NH	None	NS	Speech Processed Training	**Newly developed test** Environmental sound identification Talker- gender identification Talker discrimination	Familiarization (brief) Pre-training test Training Post-training test	1 session	L Computer based ST Individual	+	NT
22	Sweetow & Sabes (2007)	65 65	65 0	HL (NS)	HA	6m to 44y	Listening & Communication	**Standardized test** Quick Speech-in-Noise Test (Killion et al. 2004)	Group One (immediately trained) Pre-training Test: Baseline Training: 4wk	20 sessions 30min	H Computer based	+	Yes 8w

							Enhancement (LACE)	Hearing Handicap Scale for the Elderly (HHIE) (Ventry & Weinstein 1982; Newman et al. 1990) Communication Scale for Older Adults (CSOA)	Mid-training test Post-training test 1 post-training test 2: 4wk after post-test Group two (crossover period subjects): Pre-training test: Baseline Pre-training test (after 4wk from baseline) Training: 2wk Mid-training test Post-training test Post-training test 2: 4wk after post-test 1	4wk	ST Individual		
23	Tye-Murray et al. (2011)	>100 >100	>100 0	HL (NS)	HA	NS	I Hear What You Mean	NS	NS	60min	L Computer based ST Individual	+	NT
24	Miller et al. (2007)	65 65	65 0	HL (NS)	NS	NS	Speech Perception Assessment and Training System (SPATS)	NS	NS	NS	L Computer based ST Individual	+	NT

Results of The Auditory Training Program Parameters (N=15)

Table 2 shows the parameter found from 15 programs, consists of 1. Training activities, 2. Training theme, 3. Communication Strategies, 4. Methods, 5. Approach, 6. Mode, 7. Auditory Skills, 8. Speech Stimulus, 9. Sound Stimulus and 10. Complexity of training.

In every auditory training program, they have a specific training activity; with? different type of activities conducted in each training. A total of 11 studies conducted training activity by "choosing a response from a choice on screen after listening to auditory stimuli". Among the training activities conducted in the studies were "to complete modified crossword puzzles after listening to video recordings of quips", "face-to-face activities with trainer to do analytic and synthetic exercises", "to transcribe by typing on keyboard after listening to auditory stimuli", "to complete multiple-choice questions on personal computer after listening to auditory stimuli" and "music-training session by professional music teacher".

This research work has reviewed themes used for AT in each study paper and found out that most of the studies did not specify themes for their training but instead explained the materials used in their training. As such, this study categorizes the research themes in four training groups; 1. Topics, 2. Sounds, 3. Spoken Language and 4. Song. The topics used in the studies varies from multiple subjects such as health issues, money matters, exercise, restaurant, travel, family, sports, history, art and science. The sounds included are? human, animals, environmental and musical instruments. In addition, spoken language also included and covered all speech-language chunk from phonotactic, syllable and sentences. Selected songs were nursery rhymes and well-known folk songs.

In helping the subjects to achieve auditory skills after attended the AT, most research used various communication strategies such as using helpful hints or clue, interactive communicative strategies and giving support or encouragement to subjects to continue the training. However, seven programs (P06, P08, P10, P11, P13, P14, P15) did not specify any communication strategies.

From literature, AT method was defined by two trainings: analytic training or synthetic training. However, this study showed only one program used analytic and synthetic methods in the training. Other 14 program did not specify any methods used.

Most of studies did not state clearly what type of approach (either bottom up or top-down approach) that they used in their programs. Only four programs stated they used bottom up or top-down approach, but another three programs stated they "increased difficulties when correct response were given and decreased difficulties when wrong response were given:".

Three modes of auditory training were found from 15 programs namely; auditory-only (AO), auditory-visual (AV) and visual-only (VO). Some programs combined the mode with visual aid or feedback (VAF). In general, AT programs used AO with VAF.

Five auditory skills focused and targeted found in 15 programs; discrimination, identification, comprehension, auditory memory and localization.

Eleven speech stimuli were targeted in 15 programs; vowel, phoneme, syllable, word, spondee, sentence, paragraph, narrative, nursery rhymes, song and speech. Speech stimuli is based on the language of the speaker.

There was also program that targeted sound stimulus; environmental sounds stimulus and melodic contour. However, majority of the AT programs (nine out of 15) did not used any sound stimulus.

A total 17 parameters on how stimulus was presented in training named 'complexity of training' has been found in 15 programs which presented from most audible to least audible in training include; 1. Background noise (absence/ presence) found in nine programs, 2. Distance (close/ distance) found in three programs, 3. Repetition (repeated/ once) found in 12 programs, 4. Length of Utterance (short/ long) found in eight programs, 5. Complexity of utterances (simple/ complex) found in six programs, 6. Rate of utterances (slow/ individual) found in seven programs, 7. Suprasegmental (emphasis/ little or no emphasis) found in eight programs, 8. Segmental (emphasis/ little or no emphasis) found in six programs, 9. Target position (end/ middle / initial) found in one program, 10. Set (close/ open) found in five programs, 11. Speaker Familiarity (familiar/ unfamiliar) found in five programs, 12. Authenticity of sounds (degraded/ undegraded) found in four programs, 13. Sounds Origin (live/ recorded) found in 15 programs, 14. Learning Effect (adapted/ new) found in ten programs, 15. Learning Style (active/ passive) found in 13 programs, 16. Stimulus presentation (in-sequence/ random) found in seven programs and 17. Stimulus Context (in-context/ out of-context) found in five programs.

TABLE 2 DESCRIPTIVE SUMMARY OF THE AUDITORY TRAINING PROGRAM PARAMETERS

ID	AT Name	ID	Training Activities	Training theme	Method	Approach	Mode	Auditory Skills	Speech Stimulus	Sound Stimulus	Complexity of Training
P01	Listening and Communication Enhancement (LACE) (Sweetow and Sabes, 2006)	1, 11, 22	to choose a response from a choice on screen after listening to auditory stimuli	Topics health issues money matters exercise	NS	-when correct: increase difficulties -when wrong: decrease difficulties	Auditory-only and auditory-visual with visual aid/ feedback	identification comprehension auditory memory	word sentence speech	none	background noise length of utterance complexity of utterances rate of utterances speaker familiarity authenticity of sounds sounds origin learning effect learning style stimulus presentation stimulus context
P02	Customized Learning: Exercises for Aural Rehabilitation (clEAR) formerly known as: I Hear What You Mean Tye-Murray, Sommers, & Barcroft, 2011)	2, 23	to choose a response from a choice on screen after listening to auditory stimuli	Topics restaurant travel family sports	NS	bottom-up and top-down	Auditory-only with visual aid/ feedback	identification discrimination comprehension	phoneme word sentence paragraph	none	background noise repetition length of utterance complexity of utterances target position set speaker familiarity sounds origin learning effect learning style stimulus presentation stimulus context
P03	ReadMyQuips (RMQ; http: sensesynergy. com/)	3, 14, 15	to complete modified crossword puzzles after listening to video recordings of quips	NS	NS	bottom-up and top-down	Auditory-only, Visual-only and Auditory-visual with visual aid/ feedback	identification discrimination comprehension	syllable word narrative	none	background noise distance complexity of utterances rate of utterances segmental sounds origin stimulus presentation

P04	Audiologic Rehabilitation Classes (Preminger and Ziegler, 2008)	4, 9	Face to face activities with trainer Analytic exercises: to discriminate and identify phonemes synthetic exercises: (topic will be introduced for each exercise), i. answering questions about presented paragraph and ii. repeating sentences (varies in length)	NS	Analytic and synthetic	NS	Auditory-only and Auditory-visual	discrimination identification comprehension	phoneme syllable sentence paragraph	none	background noise distance repetition length of utterance speaker familiarity sounds origin learning style stimulus presentation stimulus context
P05	Environmental Sound Training (Shafiro, 2008)	5, 8	to choose a response from a choice on screen after listening to auditory stimuli	Sounds human and animal vocalizations and bodily sounds mechanical sounds of interacting inanimate solids water-related sounds aerodynamic sounds electric and acoustic signalling sounds	NS	NS	Auditory-only with visual aid/ feedback	identification	none	environmental sounds	repetition authenticity of sounds sounds origin learning effect learning style stimulus presentation
P06	Speech Processed Training (Loebach, Pisoni and Svirsky, 2009)	6, 21	to transcribe by typing on keyboard after listening to auditory stimuli	Songs and Spoken Language familiar nursery rhymes 140 meaningful Harvard sentences contained five keywords e.g., the ripe taste of cheese improves with age. 60 meaningful sentences contained four keywords e.g., fresh bread smells great environmental context in four categories: general home, kitchen, office, and outdoors	NS	NS	Auditory-only and auditory-visual with visual aid/ feedback	discrimination identification comprehension	sentence nursery rhymes	environmental sounds	repetition rate of utterances speaker familiarity authenticity of sounds sounds origin learning effect learning style

P07	Musical Instruments training program (Driscoll et.al, 2009)	7	to choose a response from a choice on screen after listening to auditory stimuli	Sounds three simple melodic patterns from 8 musical instruments; - flute - clarinet - saxophone - trumpet - trombone - violin - cello - piano	NS	NS	Auditory-only with visual aid/ feedback	dentification	none	environmental sounds	- repetition - sounds origin - learning effect - learning style
P08	Speech Perception Assessment and Training System (SPATS) (Miller et.al., 2007)	10, 24	to choose a response from a choice on screen after listening to auditory stimuli	Spoken Language the sentence module; contains spoken words (target words) in the onset, nucleus or coda e.g., if a target word was "pat", a foil might be "brat", "path" or "pit syllable constituent module; 45 onsets, 28 nuclei and 36 codas (onsets in word initial syllables, of nuclei in the stressed syllables of words, and of the word-final codas)	NS	bottom-up and top-down	Auditory-only with visual aid/ feedback	- discrimination - identification - comprehension	- sentence - narrative - phoneme - syllable - word	none	- background noise - repetition - length of utterance - complexity of utterances - suprasegmental - segmental - set - sounds origin - learning effect - learning style - stimulus context
P09	Speech-in-noise and Localization Training (Tyler et.al. 2010)	12	to choose a response from a choice on screen after listening to auditory stimuli	Spoken Language and Sounds 12 spondee words sounds: fog horn, car horn, crowd cheering, drums, door knock, ocean waves, police siren, train, applause, bugle, cat meowing, children laughing, elephant trumpeting, motorcycle engine, bell ringing, and warning siren	NS	-when correct: increase difficulties -when wrong: decrease difficulties	Auditory-only and auditory-visual with visual aid/ feedback	localizations comprehension	spondee	environmental sounds	- background noise - distance - repetition - suprasegmental - set - sounds origin - learning effect - learning style - stimulus presentation

P10	The Brain Fitness™ cognitive Training (Posit Science Corporation, San Francisco, California)	13	to complete multiple-choice questions on personal computer after listening to auditory stimuli	Topics history art science	NS	NS	NS	comprehension auditory memory	syllable sentence	none	background noise repetition suprasegmental set sounds origin stimulus context
P11	Computer-Assisted Speech Training (CAST) program developed at House Ear Institute	16	to choose a response from a choice on screen after listening to auditory stimuli	Spoken Language vowel and consonant contrasts were trained, using monosyllable words (ie, "seed" versus "said" versus "sad" versus "sawed")	NS	bottom-up and top-down	Auditory-only with visual aid/ feedback	Discrimination Identification comprehension	phoneme syllable word sentence speech	melodic contour	suprasegmental sounds origin learning style
P12	The Musical Ear-Training Program (Petersen et.al. 2012)	17	Music-training session by professional music teacher to choose a response from a choice on screen after listening to auditory stimuli	Spoken Language and Sounds singing: to vocalize and imitate short phrases with a range of vowels. playing: to imitate short phrases and to play well-known folk and children's songs with a limited range of notes on the piano. listening: to identify and distinguish simple well-known monophonic melodies played on piano.	NS	-when correct: increase difficulties -when wrong: decrease difficulties	Auditory-only with visual aid/ feedback	discrimination identification comprehension	phrase song vowel	melodic contour	repetition length of utterance complexity of utterances rate of utterances suprasegmental segmental sounds origin learning effect learning style stimulus presentation

P13	Perceptual Learning of Degraded Speech Training (Wayne and Johnsrude, 2012)	18	to choose a response from a choice on screen after listening to auditory stimuli	Spoken Language 30 simple, declarative sentences with a range of lengths (6 to 13 words per sentence) sentences were assigned to six sets of five sentences each, such that they were matched item by item for number of words, spoken duration, naturalness, and imageability	NS	NS	Auditory-only and auditory-visual with visual aid/ feedback	identification comprehension	word sentence	none	repetition length of utterance complexity of utterances rate of utterances suprasegmental segmental authenticity of sounds sounds origin learning effect learning style
P14	Talker-identification Training (Krull and Luo, 2012)	19	to choose a response from a choice on screen after listening to auditory stimuli	Spoken Language 320 sentences (80 sentences x 4 lexical categories each). key words in each sentence are controlled for word frequency (i.e., how often the word occurs in english) and neighborhood density (i.e., the number of phonemically similar words). key words belong to one of four lexical categories representing orthogonal combinations of word frequency (high or low)	NS	NS	Auditory-only with visual aid/ feedback	dentification	word sentence	none	background noise repetition length of utterance rate of utterances suprasegmental segmental sounds origin learning style

P15	Vowel identification Training Program (Richie and Kewley-Port, 2008)	20	to choose a response from a choice on screen after listening to auditory stimuli	Spoken Language 10 english vowels /i, i, e, e, æ, a, ã, o, o, u/ in isolated monosyllables presented in a variety of cvc contexts; either some real words, such as bib /bib/, and phonotactically plausible nonwords, such as beeb /bib/ the words were composed of cvc, cvcc, and ccvc strings. the words were balanced for the 10 vowels; in the set of 40 words, there were four instances of each vowel. 10 sentences spoken by the female talker and a different 10 sentences spoken by the male talker were used.	NS	NS	Auditory-only with visual aid/ feedback	discrimination Identification comprehension	vowel syllable sentence	none	background noise repetition length of utterance rate of utterances suprasegmental segmental set speaker familiarity sounds origin learning effect learning style

DISCUSSION

This study has covered a total of 24 papers from 2007 to 2017 and 3 papers from grey search. The grey search papers have been included due their significance in describing the programs used; Listening and Communication Enhancement (LACE) (R. Sweetow & Henderson Sabes, 2007), I Hear What You Mean or Customized Learning Exercise for Aural Rehabilitation (cIEAR) (Tye-Murray et al., 2011) and Speech Perception Assessment and Training System (SPATS) (Miller et al., 2007). Other established programs found in the study include; ReadMyQuips (RMQ) (Rishiq et al., 2016), The Brain Fitness™ Cognitive Training (Anderson et al., 2012) and Computer-Assisted Speech Training (CAST) (Fu & Galvin, 2007). Other nine studies are newly developed programs covering; Audiologic Rehabilitation Classes (Preminger & Ziegler, 2008), Environmental Sound Training (Shafiro, 2008), Speech Processed Training (Loebach et al., 2009), Musical Instruments Training (Driscoll et al., 2009), Speech-in-noise and Localization Training (Tyler et al., 2010), The Musical Ear Training (Petersen et al., 2012), Perceptual Learning of Degraded Speech Training (Wayne & Johnsrude, 2012), Talker Identification Training (Krull et al., 2012) and Vowel Identification Training (Richie & Kewley-Port, 2008).

Based on findings of the scoping review, this study envisaged that AT program can be explained in two categories, the AT designs and parameters. The AT designs consisted of sample size, hearing status, measurement test, research sequence, duration, frequency, length of training, location of training, AT delivery style (either face-to-face, with or without trainer, individual or group training), findings and retention effect. The AT parameters on other hand included AT name, training activities, training theme, method, approach, mode, auditory skills, speech stimulus, sound stimulus and complexity of training.

The sample size in each study was varied from 2 to 279 subjects. Even with small sample size, the study was able to show positive findings as found from study by Rao et al. (2017) whereby, two subjects were able to conclude the other subjects trained using RMQ with marked improvement in their speech perception in noise when tested with Hearing in Noise Test (HINT). This was due to the comparisons made, in-between before and after training within subjects. There were also small sample size studies that compare between training group and control group. Study by Richie & Kewley-Port (2008) has compared between these two groups used seven subjects for each group also able to conclude a positive finding; vowel improvement in auditory-visual speech recognition under difficult listening conditions. A bigger sample size was used in study by Saunders et al. (2016) where they compared between 279 subjects in training group with 263 subjects in control group. This has enabled to result in a positive finding. As such, this can be concluded that AT program effectiveness can be proven even with small number of sample size. This conclusion is based on the premise that a program's impact can be evident and statistically significant even if the number of participants in the study is limited. Small sample sizes can still yield valuable insights and contribute to the understanding of the program's effectiveness, especially if the results are consistent and statistically significant, though larger sample sizes may enhance the robustness and generalizability of findings

One consideration needs to be taken when measuring the effectiveness of an auditory training program is the pre-training performance/ baseline. Saunders et al. (2016) suggested that the subjects with poorer baseline will yield a greater gain when tested using Words-in Noise test (WIN), Hearing Handicap Inventory for Adults/Elderly (HHIA/E) or Abbreviated Profile of Hearing Aid Performance (APHAP). This implies that individuals with lower initial hearing abilities may experience more significant improvements due to greater room for improvement before they reach their maximum potential as compared to the individuals with higher initial hearing abilities with smaller room of improvements. This may introduce bias in assessing the effectiveness of auditory training programs, as individuals who already have a certain level of ability might show improvement, but not necessarily yield greater improvements due to their initial abilities. It highlights the need to consider baseline abilities and their impact on the assessment of program effectiveness. This can be done through the use of normalized gain in measuring the effectiveness of an auditory training program. Normalized gain allows for a fair evaluation by considering the starting point of each participant and ensuring that improvements are measured accurately relative to their initial abilities (Coletta & Phillips, 2005).

With regard to hearing status, 17 studies used subjects with hearing loss ranging from mild to profound hearing loss. Tyler et al. (2010) stated that a systematic hearing training is viable for subjects with hearing loss from mild to profound hearing loss by improving the subjects binaural hearing in noise and localization. However, most studies used subjects with mild to moderate hearing loss (8 studies) and explained why from this review, it was found that most of the devices used was hearing aids because Ferguson et al. (2015) stated that hearing aids are most effective for those with mild to moderate hearing loss. There were also studies that investigate on normal hearing subjects using simulations devices to represent hearing-impaired subjects. The findings on using normal hearing subjects revealed that it will be practical and useful to generalize for the hearing-impaired subjects to undergo an auditory rehabilitation (Gfeller et al., 2015 and Loebach et al., 2009). Therefore, the study using normal hearing subjects has been included in this scoping review since the result has shown significant implications to hearing-impaired subjects and it enabled to be used to design a new AT program. When we look at hearing age, most studies did not state the subjects hearing age. Only 11 studies use hearing age as part of their study ranging from one month to 44 years. However, a minimum of 4 weeks of hearing age is recommended to be included in research to allow acclimatization to hearing devices (Saunders et al., 2016 and Rishiq et al., 2016). This has give suggestion to this study to not specified the hearing age as one of the inclusion criteria.

Standardized test, newly developed test for the research work or a combination of both measurements were done to measure the AT performances of each study. Standardized test that has been used were Word-in-noise test (WIN) (Miller et al., 2015; Saunders et al., 2016 and Smith et al., 2016) Handicap Inventory (HHI) (Preminger & Meeks, 2010 and Saunders et al., 2016) Hearing-in-noise Test (HINT) (Fu & Galvin, 2007; Rao et al., 2017 and Tyler et al., 2010), The Abbreviated Profile of Hearing Aid Performance (APHAP) (Miller et al., 2015; Saunders et al. 2016 and Smith et al., 2016) and Multimodal Lexical Sentence Test for Adults (MLST-A) (Yu et al., 2017 and Rishiq et al. 2016). The newly developed tests were needed to contemplate the essence of the training in different perspective following the study methodology. Shafiro (2008), Driscoll et al. (2009), Loebach et al. (2010) and Petersen et al. (2012) used the training stimulus itself to test subjects' performances. According to R. Sweetow and Palmer (2005), it is essential that auditory training programs utilize a measurement system that is highly sensitive and capable of accurately gauging the program's effectiveness. This sensitivity ensures that the measurement is precisely aligned with what the program is intended to assess and evaluate. Thus, when developing a new auditory program, incorporating the training stimulus as the tools to measure the effectiveness of the program can be considered. The incorporation of training stimulus and a purpose-built assessment tool, may not only evaluate the effectiveness of the program but also its ability to address specific auditory training goals and objectives.

The training sequence in each study was dependent on the objectives of their research. For example research by Shafiro et al. (2015), Tyler et al. (2010) and Rao et al. (2017) used 30 minutes per session training with pre-training test, training and post-training sequence; targeting to see the effect of the training by comparing pre and post training findings. While study to investigate retention effect have conducted second post-training test, for example in study by Saunders et al. (2016) and Smith et al. (2016), they did second post-training test after six months of the training. There were also researches that have conducted another test upon pre-training test to see baseline of all subjects as shown in study by Shafiro (2008) and Rishiq et al. (2016). While study by Loebach et al. (2009, 2010) introduced familiarization step before pre-testing to attain acclimatization on the training materials to all subjects to avoid bias. Therefore, this study review suggested that all training should be well prepared for the research sequence based on the research objectives to achieve anticipated goal.

Based on research, most study (91%) are leaning to use computer-based program or computer-based style. R. W. Sweetow & Sabes (2007), (Fu & Galvin, 2007) and Shafiro et al. (2015) stated, study that used self-training computer-based is cost effective in terms of money and time. While, study by Preminger & Meeks (2010) and Preminger & Ziegler (2008) that used face-to-face style focused on the study of group and with spouse to evaluate the quality of life among hearing impaired adult. In conclusion, we may suggest that computer-based program are more cost and time effective, but the use of traditional face-to-face training serves the closeness to real-life situation; using real voice, real setting and real feedback from trainer. Therefore, this study suggested to develop a face-to-face training for

new program to ensure the trainer could deal with the trainees emotional and practical aspect of AT. The training should be also held in clinical setting or laboratory to maintain all variables that may affect the training. This is based on suggestion made by Boothroyd (2007) that adult aural rehabilitation should optimize auditory function by controlling the listening environment in training and the need to have counselling to deal with emotionally and practically among individual with post-lingual hearing loss.

Regarding training duration, frequency and length of training, most study stated that they set their study in such a specific stipulated time based on two reasons; 1. They determined training duration, frequency and length of training based on research protocol (Rishiq et al., 2016) or 2. They integrated their studies with duration to finish the AT program which already stated in previous study (Richie & Kewley-Port, 2008). Based on findings of scoping review for most studies, the ideal training duration, frequency and length for face-to-face training around 30 to 60 minutes, minimum ten sessions in four to 12 weeks are recommended.

The variables of nine parameters explained that the strategy in each program should be; 1. Training activities, 2. Training theme, 3. Method, 4. Approach, 5. Mode, 6. Auditory skills, 7. Stimulus (speech or sound) and 8. Complexity of training. All parameters should be set according to research objectives, or the AT program aims. An established program such as cIEAR (Tye-Murray et al., 2011), LACE (R. W. Sweetow & Sabes, 2007) and SPATS (Miller et al., 2007) has specific parameters and conducted in laboratory. The suggestion has been made not only to answer the importance of having traditional style for AT program, but to help both trainee and trainer to achieve the best possible outcomes when conducting a standardized AT program.

CONCLUSIONS

The main objective of this scoping review is to review auditory training program in literatures and investigate the program trend. To achieve its specific goals the auditory training program has been designed meticulously through reviewing 24 papers included in this study and identifying 15 auditory training programs with each program has an exceptional ***design*** but shared practically the same ***parameters***. Saidi & Castro (2021) believed that auditory training, when chosen specifically according to each patient's needs, can enhance speech understanding.

The AT program ***designs*** explained; 1. sample size, 2. hearing status, 3. hearing devices, 4. hearing age, 5. measurement test, 6. training sequence, 7. training durations, 8. Training frequency, 9. length of training, 10. location of training, 11. training delivery style; either computer based or face to face, with trainer or self-training and individual or group training, 12. findings and 13. retention effects.

The parameters are the structure that scaffold the program that make auditory training as it meant to be. Therefore, the parameters that build an auditory training program need to be produced uniformly but tailored to the individual who needs it. The ***parameters*** used in auditory training program contains 1. Training activities, 2. Training theme, 3. Communication strategies, 4. methods, 5. approaches, 6. mode, 7. auditory skills, 8. speech stimulus, 9. sound stimulus and 10. complexity of training.

Research finding is optional to use as a guideline to develop an auditory training program designs and parameters. However, the designs and parameters should be carefully chosen for each individual with hearing impairment to heighten the improvement gain which benefit both trainer and trainee.

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