ORIGINAL ARTICLE

Acoustic Complexity Variables Used in Adult Auditory Training: A Scoping Review

Sarah Rahmat [1*,2,3], Nadia Munira Mustafa[4], Juliana Aminah Marhaban[1]

[1]Department of Audiology and Speech-Language Pathology, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia, Pahang, Malaysia
[2]Integrated Omics Research Group (IORG), Kulliyyah of Allied Health Sciences, International Islamic University Malaysia, Pahang, Malaysia
[3] Children Health and Wellbeing Research Group, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia, Pahang, Malaysia
[4] InnoHear, No 23A, Pusat Komersial Batu 3, Sungai Isap, 25150 Kuantan, Pahang, Malaysia

ABSTRACT

Background: Auditory training is a crucial component of aural rehabilitation for individuals with hearing loss, aiming to enhance speech perception and device satisfaction. The effectiveness of such training is influenced by various acoustic complexity variables that determine task difficulty. This scoping review aims to compile the acoustic complexity variables used in adult auditory training programs and examine effectiveness trends in programs that incorporate specific acoustic complexities. **Methodology:** A comprehensive literature search was conducted across four databases using keywords such as 'hearing loss,' 'auditory training,' 'hearing aids,' 'cochlear implants,' 'perceptual learning,' 'aural rehabilitation,' 'auditory rehabilitation,' and 'adults,' yielding 220 articles, of which 29 met the inclusion criteria. Data was extracted and analysed using descriptive and thematic analysis, following the Joanna Briggs Institute (JBI) framework. **Results:** The review identified 17 acoustic complexity categories in auditory training. All 29 studies used recorded sounds, while only 6.9% included both recorded and live sounds. Key variables linked to 100% positive outcomes were: Complexity of Utterance (Simple), Learning Style (Passive), Distance (Close), Segmental (Little or No Emphasis), and Stimulus Context (Out of Context). On the other hand, Distance and Sound Origin (Live) were linked to no significant differences in outcomes in 27% and 50% of studies, respectively. **Conclusion:** Acoustic complexity variables play a vital role in auditory training outcomes. Future research should explore a progression from least to most complex variables, enabling individuals with hearing loss to improve their auditory skills progressively, ultimately enhancing real-world speech perception and communication abilities.

Keywords:
Acoustic complexity, Auditory training; Aural rehabilitation; Adults; Hearing loss

INTRODUCTION

Individuals with hearing loss typically experience a reduction in speech audibility and quality of life. Amplification devices, such as hearing aids and cochlear implants, are designed to enhance audibility and communication while reducing perceptual handicaps. However, despite the benefits of these devices, many users continue to struggle with complex listening tasks, particularly in noisy environments (Voola et al., 2024). This difficulty arises because speech perception in noise requires cognitive abilities such as processing speed, working memory, and attention to focus on speech sounds while ignoring background noise. Unfortunately, these cognitive abilities are often diminished in individuals with hearing loss, especially among adult listeners (Maren et al., 2019).

To alleviate the listening challenges faced by adults with hearing impairment, auditory training can be implemented. This intervention has been shown to improve speech perception and device satisfaction among users (Casserly et al., 2019). Auditory training serves as a compensatory mechanism for the degradation of auditory signals experienced by individuals with hearing loss (Sweetow & Palmer, 2005). Several parameters are utilized in auditory training programs, including: 1) training activities, 2) training themes, 3) communication strategies, 4) methods, 5) approaches, 6) modes, 7) auditory skills, 8) speech stimuli, 9) sound stimuli, and 10) complexity of training components (Marhaban et al., 2023). The effectiveness of auditory training has been demonstrated

* Corresponding author
E-mail address: sarahrahmat@iium.edu.my

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by numerous researchers who report improvements in speech sound perception (Fallahnezhad et al., 2023). For example, Beier et al. (2015) conducted a systematic review that identified the effectiveness of auditory training for individuals with hearing loss. They found that hearing aid users benefit from auditory training programs, particularly from tasks that involve cognitive demands. This study suggests that the types of tasks and the acoustic complexity variables used during training can significantly influence the effectiveness of auditory training (Beier et al., 2015).

Acoustic complexity in this paper refers to the variation in sound characteristics that influence how auditory stimuli are perceived and processed. It also refers to how stimulus is being presented which can influence the audibility of speech from most audible (least complex) to least audible (most complex) (Marhaban et al., 2023). This includes factors such as the frequency, intensity, and temporal patterns of sounds, as well as the phonetic similarity between words. In auditory training, manipulating acoustic complexity can enhance or hinder the learning process by affecting the listener's ability to discriminate between sounds and recognize speech in various contexts. Training programs that incorporate a range of acoustic complexities—such as different talkers, background noise levels, and types of stimuli—can better prepare individuals with hearing loss to navigate real-world listening environments, ultimately improving their speech perception and communication skills. Many studies have been conducted to investigate the relationship between acoustic complexity variables used in auditory training programs and speech sound perception's improvement. For example, Burk et al. (2006) investigated the effectiveness of word-based auditory training and found that both young normal-hearing and older hearing-impaired listeners performed significantly better on trained word lists compared to untrained lists presented by the same speaker. Improvements in untrained words were small but significant, indicating some generalization to new words. The substantial gains in trained words persisted even with different speakers, suggesting that listeners focused more on memorizing the words rather than specific acoustic features of the speaker. Six months later, participants still showed improved performance on trained words compared to their initial scores. However, when trained words were placed in sentences, there was no improvement in recognition over untrained words, indicating that the complexity of sentences may limit generalization. This study highlights how the type of acoustic complexity used in training—such as trained versus untrained words, and single words versus sentences—can affect how well auditory training works.

To the best of the author's knowledge, no study has yet identified which acoustic complexity variables are used in adult auditory training programs. Therefore, this scoping review aims to compile the acoustic complexity variables used in adult auditory training programs and examine effectiveness trends in programs that incorporate specific acoustic complexities. Using the Joanna Briggs Institute (JBI) framework, this review will synthesize existing knowledge, address literature gaps, and offer recommendations for future research, with the goal of enhancing auditory training programs for adults with hearing difficulties.

METHODOLOGY

A scoping review was employed in this study due to its ability to map out key concepts and compile evidence from a wide range of sources. The methodological framework proposed by the Joanna Briggs Institute (JBI) was utilized, as it offers a comprehensive and structured approach to conducting scoping reviews. This process included several critical stages (1) identifying the research questions, (2) developing inclusion and exclusion criteria, (3) data searching, (4) data selection, (5) data extraction and charting, and (6) data analysis (Peters et al., 2020).

Research Questions

This study was guided by two specific questions: "What types of acoustic complexity variables are used in adult auditory training programs?" and "What are the effectiveness trends of auditory training programs that incorporate the acoustic complexity variables?"

Eligibility Criteria

Criteria of study participants

Studies were included if they involved adult participants with any degree of hearing loss using hearing aids, cochlear implants, or other listening devices, as well as normal-hearing subjects recruited for auditory training program validation. Studies involving children with hearing loss, animals as subjects, or participants with diseases or pathological conditions were excluded.

Criteria of study characteristics

Studies published in English or Malay that compared the intervention group (participants who received auditory training) with the control group, or included repeated measurements (pre- and post-comparison), were included. The review also included studies that used randomized controlled trials, non-randomized controlled trials, cohort studies, repeated measures (pre- and post-training comparisons), case studies, reliability tests, and validity tests as study designs.

Data searching

A systematic search of four databases—PubMed (6 results), ScienceDirect (48 results), Scopus (70 results), and ProQuest (92 results)—yielded 216 articles. An additional four articles were gathered from a grey literature search, bringing the total to 220 articles for further screening and review. All articles were systematically searched using keywords such as 'hearing loss,' 'auditory training,' 'hearing aids,' 'cochlear implants,' 'perceptual learning,' 'aural rehabilitation,' 'auditory rehabilitation,' and 'adults.' The data search was conducted from November 2020 to January 2021.

Data selection

A total of 220 articles identified through the data search underwent a three-stage screening process based on the inclusion criteria. First, 19 duplicate articles were removed, leaving 201 articles for further screening. In the second stage, titles and abstracts were reviewed, resulting in the exclusion of 165 articles that did not meet the inclusion criteria. The remaining 36 full-text articles were then assessed for eligibility in the third stage. During this stage, 7 articles were excluded because they either did not meet the inclusion criteria or met the exclusion criteria. After completing all three stages of screening, 29 articles were selected for further analysis in this review. Three reviewers participated in the screening process, and any disagreements or uncertainties were resolved through discussion to reach a consensus. Figure 1 shows the flow diagram of the data search and selection process.

Data extraction and charting

Information from the selected studies was extracted and organized into a table (Table 2), categorizing the following details: authors, year of publication, research objective, study design, participant characteristics (sample size, age, hearing status—whether hearing loss or normal hearing—and type of amplification device used), auditory training background (name or description of the auditory training), training protocol (procedures), and outcome measurements, including the study's effectiveness. Data extraction was carried out by two reviewers, and any discrepancies were resolved through discussion. The extracted data was then verified by a third reviewer.

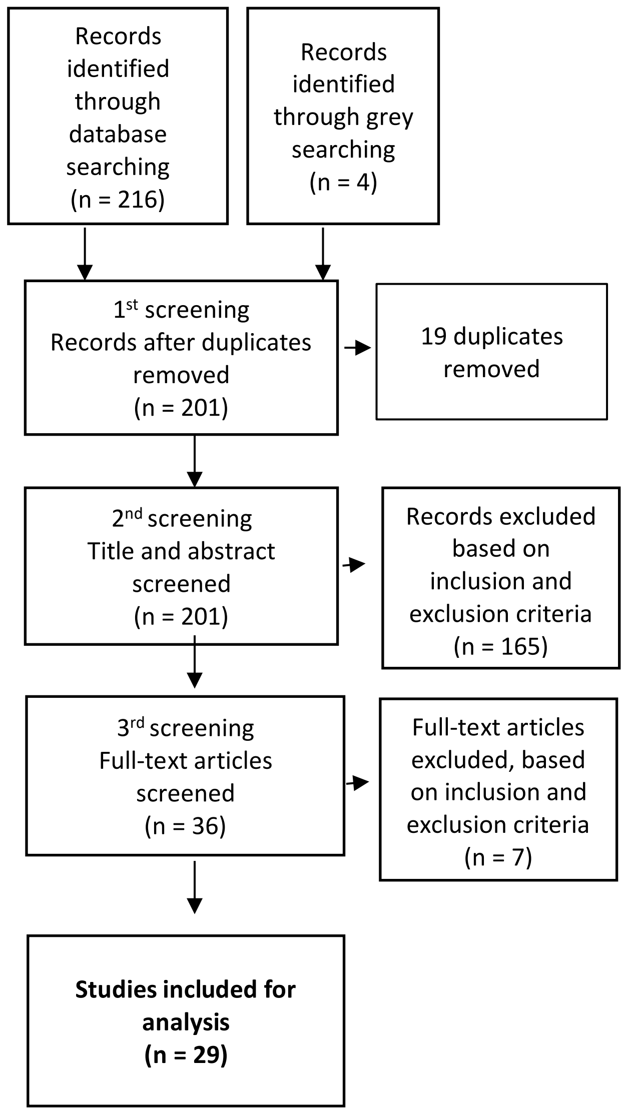

Figure 1: Flow diagram of the data search and selection process.

Data analysis

A descriptive summary table of adult auditory training programs that met the inclusion criteria was created to present the findings from the included studies (see Table 2). The effectiveness of each study was categorized as follows: positive findings (+) were assigned when a significant improvement was observed in at least one of the outcome measures after auditory training. Findings were categorized as 'no difference' (ND) when no significant improvement or difference was found between pre- and post-training measures, or between the control and training groups, across all outcome measures. If no outcome measures were reported (e.g., studies that only described the program's development without assessing its effectiveness), the effectiveness was categorized as 'no available findings' (NA).

Thematic analysis was then employed to analyse and categorize the types of acoustic complexity variables used in auditory training programs, based on previous literature. A deductive approach was applied, with the categorization of information guided by existing concepts and frameworks. The table of definitions used to categorize the acoustic complexity variables is based on the definitions listed in Table 1 below.

Table 1: Definition of acoustic complexity variables

Acoustic Complexity	Variables	Definition
Authenticity of Sounds	Undegraded, Degraded	Refers to the quality of sound; undegraded sounds maintain their original quality, while degraded sounds have been altered to reduce redundancy.
Background Noise	Absence, Presence	Refers to ambient noise that competes with speech signals; absence indicates a quiet environment, while presence signifies the existence of competing noise.
Complexity of Utterances	Simple, Complex	Refers to the structure of utterances; simple utterances utilize straightforward language rules, while complex utterances incorporate various linguistic elements, making them harder to understand.
Distance	Close, Distance	Refers to the distance between the listener and the sound source; indicates proximity (close) or separation (distance).
Learning Effect	New, Adapted	Refers to the improvement in performance on tests due to familiarity with the testing process or items; new items are introduced, while adapted items have been modified for better understanding.
Learning Style	Passive, Active	Refers to the preferred methods of learning; passive learning involves receiving information without direct engagement, while active learning includes self-training or interactions with a trainer.
Length of Utterance	Short, Long	Refers to the length of spoken expressions; short utterances consist of brief phrases or words, while long utterances encompass complete sentences or extended discourse.
Rate of Utterances	Slow, Individual/Normal Conversation	Refers to the speed of spoken expression; slow rates indicate a measured pace, while individual or normal conversation rates reflect typical speech patterns.

Repetition	Once, Repeated	Refers to the occurrence of spoken elements; once indicates a single instance, while repeated involves multiple occurrences of the same phrase or action.
Segmental Features	Little/No Emphasis, Emphasis	Refers to Individual segment of spoken language; little or no emphasis indicates a flat delivery, while emphasis highlights certain syllables, words or phrases to convey meaning.
Suprasegmental	Little/No Emphasis, Emphasis	Refers to the prosodic aspects of speech; little or no emphasis indicates a monotone delivery, while emphasis involves variations in pitch, intensity, and rhythm to convey meaning.
Set	Closed, Open	Refers to collections of related items; closed sets contain a fixed number of known items, while open sets have no restrictions on membership, allowing for variability.
Sounds Origin	Live, Recorded	Refers to the source of sounds; live sounds occur in real-time, while recorded sounds have been captured and played back.
Speaker Familiarity	Unfamiliar, Familiar	Refers to the listener's recognition of the speaker's voice; unfamiliar indicates a lack of prior exposure, while familiar denotes previous experience with the speaker's voice.
Stimulus Context	In-Context, Out-of-Context	Refers to the circumstances surrounding a stimulus; in-context stimuli are relevant to the current situation, while out-of-context stimuli lack direct relevance.
Stimulus Presentation	In Sequence, Random	Refers to the arrangement of stimuli; in sequence indicates a structured order, while random presentation lacks a predetermined sequence.
Target Position	Initial, Middle, End	Refers to the placement of important messages within spoken language; initial indicates the beginning, middle denotes the center, and end signifies the conclusion of word, phrase, sentence, or whole message.

To determine the trend of acoustic complexity used in the auditory training program, the percentage of auditory training programs that use specific acoustic complexity variables was calculated using the following equation:

Percentage of auditory training programs that use specific acoustic complexity variables = Number of auditory *training program that use specific acoustic complexity variables / Total number of study (29) x 100*

To determine effectiveness trends in programs that incorporate specific acoustic complexities, the effectiveness of auditory training programs that utilize different acoustic complexity variables was determined using the following equation:

Percentage of effectiveness for each acoustic complexity variable in auditory training programs = (a/N) × 100%

where:

- *a represents the total number of studies that report different category of effectiveness outcomes (positive, no difference, not available) for a specific acoustic complexity variable.*
- *N is the total number of studies utilizing that specific acoustic complexity variable in auditory training programs.*

RESULTS

Overview of the studies

A total of 29 studies that were included in this scoping review study have been summarised in a table of descriptive summary of auditory training programs that met the inclusion criteria as shown in Table 2.

Table 2 illustrates that all studies included participants ranging in age from young adults to older adults, with varying levels of hearing ability, from normal hearing to mild and profound hearing loss. 12 studies involved participants using hearing aids, 10 included cochlear implant recipients, two featured users of both cochlear implants and hearing aids (bimodal users), seven studies included participants without any amplification, and one study did not report amplification status. The sample sizes for the training and control groups varied significantly, ranging from 2 to 263 participants. Additionally, Table 2 summarizes the different types of auditory training programs employed in the 29 included studies, along with their findings.

Out of 20 types of auditory training programs that are used in studies, the most used auditory training programs in studies are Listening and Communication Enhancement (LACE) and ReadMyQuips (RMQ). Both programs are classified as computer-based auditory training (CBAT), which allows participants to complete training at their leisure and it is more self-directed. The LACE program consists of five tasks, where three tasks are listening to degraded speech (speech in noise, rapid speech, competing speakers) and two tasks related to auditory memory (word memory task and missing word task). Whereas, the RMQ program is the only program that combines auditory and visual information in their training. It uses an audiovisual (AV) training approach that aims to improve communication and speechreading skills by giving tasks to complete the modified crossword puzzles after listening to video recordings of quips. The results in Table 2 also show the studies that used different types of auditory training programs, including individual training and training in groups of participants. The CBAT program, however, is the most commonly used auditory training program in the literature.

Most studies measured outcomes across four subcategories: speech intelligibility, cognition, quality of life, and musical perception. They also included two additional categories of outcome measures: 1) electrophysiology, and 2) psychoacoustic tests. Speech intelligibility was assessed using a variety of speech tests that manipulated task difficulty through different acoustic complexity variables during training. Cognitive abilities were evaluated with word memory tests, while quality of life assessments aimed to determine whether participants' hearing abilities had improved. In terms of study effectiveness, the majority of the studies (75.9%, n=22) demonstrated that auditory training programs showed positive outcomes, while a smaller percentage reported no significant impact (17.2%, n=5). The other 6.9% (n=2) of the studies did not report the effectiveness of the auditory training program. This trend highlights the potential efficacy of auditory training interventions, although it also underscores the need for further investigation into the variables influencing both positive and negative outcomes.

Acoustic complexity variables used in adult auditory training programs

Table 3 presents 17 categories of acoustic complexity utilized in auditory training programs, organized into specific types of acoustic complexity variables. Based on the results in Table 3, the most commonly used acoustic complexity variable in auditory training programs is the recorded sounds presentation variable. All 29 studies (100%) employed recorded sounds during training, while only two studies (6.9%) used both recorded and live sounds. The recorded sounds are typically presented through speakers or other assistive devices, whereas live sound presentations involve one or multiple speakers delivering stimuli such as words or sentences, positioned between the speakers and listeners. In contrast, the acoustic complexity variables that were used less

Table 2: Descriptive summary of auditory training programs that met inclusion criteria

Authors (Year) [Paper ID]	Research objectives	Study design	Participants				Name of auditory training or description	Outcome measurement	Study Effectiveness +(positive)/ ND (No differences)/ NA (Not Available)
			Sample size	Age (years)	Hearing status	Hearing device			
Fu & Galvin, (2007) [1]	Developed a computer-assisted speech- training (CAST) program to provide the means to conduct auditory rehabilitation at home; CI users' adaptation to a severe spectral mismatch over an extended learning period	Experimental and case study	N=13 1) Training group= 13 2) Control group= 0	NS	HL (NS) and NH	CI	Computer-Assisted Speech Training (CAST)	1. Hearing in Noise Test (HINT) sentence recognition thresholds in steady, speech-shaped noise 2. IEEE21 sentence recognition in quiet 3. Multitalker vowel recognition in quiet 4. Multitalker consonant recognition in quiet	+
Miller et al. (2007) [2]	To provide a much more detailed assessment of the speech- perception problems encountered by hearing-impaired clients than was previously available and then, based on that assessment, to offer a training program designed improve the clients' abilities to understand speech in everyday situations	Program development	N=65 1) Training group= 65 2) Control group= 0	NS	HL (NS)	NS	Speech Perception Assessment and Training System (SPATS)	NS	NA
Sweetow & Sabes, (2007) [3]	Development of Listening and Communication Enhancement (LACE) and to assess the effects of training with LACE	Program development and pilot test	N=65 1) Training group= 65 2) Control group= 0	28 – 85 years	HL (NS)	HA	Listening & Communication Enhancement (LACE)	1. Quick Speech-in-Noise Test 2. Hearing Handicap Scale for the Elderly (HHIE) 3. Communication Scale for Older Adults (CSOA)	+

Preminger & Ziegler (2008) [4]	To determine whether auditory-only and auditory-visual speech perception could be trained in a group format	Experimental study	N=47 1) Training group >16 2) Control group ≥16	55 to 75 years	HL (NS)	HA	Audiologic Rehabilitation Classes	1. City University of New York (CUNY) AB Isophonemic Word Lists 2. CUNY Topic Related Sentences 3. Hearing Handicap Inventory (HHI) for the elderly and adults 4. World Health Organization Disability Assessment Schedule II 5. Class evaluation form: A subjective class evaluation form	ND
Shafiro (2008) [5]	To examine whether auditory training improves listeners' identification of spectrally-degraded environmental sounds	Pretest-posttest design	N=7 1) Training group= 7 2) Control group= 0	21 to 26 years	NH	None	Environmental Sounds Training	Tested using the entire stimulus set (40 sound sources, 4 exemplars each, for a total of 160 stimuli)	+
Richie & Kewley-Port (2008) [6]	To examine the effects of a computer-based, auditory–visual vowel identification training program on sentence recognition under difficult listening conditions	Experimental study	N=14 1) Training group= 7 2) Control group= 7	19 – 28 years	NH	None	Vowel identification Training	1. Closed-set vowel identification test 2. An open-set monosyllable word recognition test 3. An open-set sentence recognition test	+
Driscoll et al. (2009) [7]	1) To compare the efficacy of repetition (RE), feedback (FB), and direct instruction (DI) on the ability to acclimatize to a distorted signal 2) To recognize simulations of the signal of musical	Experimental study	N=66 1) Training group= 66 2) Control group= 0	18 to 69 years	NH	CI	Musical Instruments training	1. Music Background Questionnaire (MBQ) 2. Paired Associate Memory Test (PAT) 3. Instrumental Simulation Recognition Test	+

Loebach et al. (2009) [8]	To assess whether training on speech processed with an eight-channel noise vocoder would produce transfer of auditory perceptual learning to the recognition of	Experimental study	N=48 1) Training group= 24 2) Control group= 24	Young adult	NH	None	Speech Processed Training	1. Environmental sound identification 2. Talker- gender identification 3. Talker discrimination	+
Loebach et al. (2010) [9]	To assess whether different types of training and feedback affect perceptual learning of speech processed with a CI simulation to evaluate the efficacy of different rehabilitation methodologies for newly implanted individuals	Experimental study	N=144 1) Training group= 96 per group 2) Control group= 48	Young adults	NH	CI	Speech Processed Training	Transcribe 20 spectrally degraded meaningful sentences	+
Preminger & Meeks (2010) [10]	1. To evaluate the effectiveness of training in communication strategies and psychosocial exercises for spouse (SPs) of person with hearing loss (PHLs) 2. To determine whether PHLs of SPs had significantly improved mood, reduced stress, improved marital communication, and better HL-QOL scores	Randomized controlled study	N=72 1) Training group= 36 2) Control group= 36	1) PHLs: i.Training (mean age = 63.5) ii.Control (mean age 72.2). 2) SPs i.Training (mean age =69.1) ii.Control (mean age = 62.4)	1) PHLs: Moderate HL 2) SPs: NH	HA= 34 CI= 2	Audiological Rehabilitation (AR) classes	1. Hearing Handicap Inventory (HHI) Elderly 2. Modified HHI-Adult 3. Modified HHI-Spouse 4. 10-item Perceived Stress Scale (PSS) 5. Affect Rating Scale (ARS) 6. Communication in the Marriage Primary Communication Inventory (PCI)	+

Tyler et al. (2010) [11]	Describes the initial development of a novel approach for training hearing-impaired listeners to improve their ability, to understand speech in the presence of background noise and to also improve their ability to localize sounds	Program development and pilot test	N=12 1) Training group= 6 2) Control group= 6	57 to 77 years	Mild to profound HL	CI	The localization and speech- in-noise modules	1. Nucleus-consonant monosyllabic words (CNC) 2. CUNY sentences 3. Hearing in Noise Test (HINT) sentences 4. Everyday sounds localization test 5. Real-world listening test for localization and recognition	+
Krull et al. (2012) [12]	To compared the efficacy of talker-identification training in two groups of young normal-hearing adults, listening to either acoustic simulations of unilateral CI or bimodal (CI+HA) hearing	Experimental study	N=30 1) Training group= 24 2) Control group= 6	18 – 25 years	NH	CI or CI+HA	Talker-Identification Training	1. Sentence-recognition using two lists of sentences (in quiet and in noise) 2. Emotion-recognition performance using 100 tokens in quiet	+
Petersen et al. (2012) [13]	Investigated the effect of a 6-month one-to- one musical ear- training program on the perception of music, speech, and emotional prosody of deaf patients receiving a cochlear implant (CI)	Experimental study	N=24 1) Training group= 15 2) Control group= 9	21-73 years	Severe HL	CI + HA	The Musical Ear-Training	Musical instrument identification (MII) 1. Melodic contour identification (MCI) 2. Pitch ranking (PR) 3. Rhythmic discrimination (RD) 4. Melodic discrimination (MD) 5. The Hagerman speech perception test (HAG) 6. An emotional prosody recognition test (EPR)	+

Wayne & Johnsrude (2012) [14]	Evaluated the contribution of visual speech information to perceptual learning when it was presented concurrently with clear auditory speech as feedback	Experimental study	N=144 1) Training group= 144 2) Control group= 0	17 -28 years	NH	None	Perceptual Learning of Degraded Speech Training	Word-report task	ND
Anderso n et al. (2012) [15]	1) To compare the effects of auditory-based cognitive training on the ratio of temporal fine structure (TFS)/ envelope in individuals with and without hearing loss. 2) To evaluate changes in perceptual and cognitive function, given evidence that successful hearing in noise relies on a complex interplay of sensory and cognitive	Experimental study	N=77 1) Training group= 38 2) Control group= 39	55 to 79 years	Mild to profound HL	None	The Brain Fitness™ Cognitive Training	1. Quick Speech-in-Noise Test 2. Two subtests of the Woodcock–Johnson Tests of Cognitive Abilities 3. The Integrated Visual and Auditory Continuous Performance Test 4. Electrophysiology test	+
Miller et al. (2015) [16]	To evaluate the efficacy of two types of computerized speech-perception training for adults who use hearing aids	Experimental study	N=240 1) Training group= 240 2) Control group= 0	35 to 89 years	Mild to moderate HL	HA	Speech Perception Assessment and Training System (SPATS)	1) Non-SPATS i. Word-in-Noise-test (Win) ii. Quick Speech-in-Noise Test iii. CID Monosyllabic Word Test in Quiet and in Noise iv. Connected Speech Test (listen Only) v. Connected Speech Test (Look and Listen) vi. The abbreviated profile of hearing aid performance (APHAP) 2) SPATS–Related	NA

Shafiro et al. (2015) [17]	To investigate the effect of a short computer-based environmental sound training regimen on the perception of environmental sounds and speech in experienced cochlear implant (CI) patients	Experimental study	N=14 1) Training group= 14 2) Control group= 0	51 to 87 years	Mild HL	CI	Environmental Sound Training	1. The Familiar Environmental Sound Test (FEST) 2. Consonant-Nucleus-Consonant (CNC), monosyllabic word recognition test 3. Speech-in-Noise (SPIN-R) sentence test	+
Rishiq et al. (2016) [18]	To determine whether hearing aids in combination with computer-based auditory training improve audiovisual (AV) performance compared with the use of hearing aids alone	Experimental study	N=24 1) Training group= 12 2) Control group= 12	1) Training group: range = 51–84 years 2) Control group: range= 62-81 years	Mild to moderate HL	HA	ReadMyQuips (RMQ)	The Multimodal Lexical Sentence Test for Adults (MLST-A)	ND
Saunders et al. (2016) [19]	To examine the effectiveness of the Listening and Communication Enhancement (LACE) program as a supplement to standard-of-care hearing aid intervention in a Veteran population	Multisite randomized controlled trial	N=243 1) Training group= 206 2) Control group= 73	66 to 71 years	Mild to moderate HL	HA	Listening and Communication Enhancement (LACE)	1. Word-in-Noise-test (WIN) 2. NU-6-word lists (Wilson et al. 1994) 3. Modified NU-20 test 4. Wechsler Adult Intelligence scale 3rd Edition WAIS-II)I 5. The Low Predictability Sentences performance on the multi-SNR R-SPIN 6. Abbreviated Profile of Hearing Aid Performance (APHAP) 7. HHI for the elderly and adults	ND

Smith et al. (2016) [20]	1) To determine if patient characteristics or clinical variables could predict who benefits from individual auditory training 2) To determine if at-home AT with the LACE programs were more effective than placebo training or simply providing a single session of educational	Multisite and randomized controlled clinical trial (RCT) study	N=263 1) Training group= 193 2) Control group=70	Older Veterans (mean age = 68.6, SD= 7.7)	Mild to moderate HL	HA	Listening and Communication Enhancement (LACE)	1. Word-in-Noise-test (WIN) 2. HHI for the elderly and adults 3. The abbreviated profile of hearing aid performance (APHAP)	+
Tye-Murray et al. (2016) [21]	This study determined whether auditory training with the speech of an individual's frequent communication partner in this case their spouse, would lead to enhanced recognition of their spouse's speech	Experimental study	N=10 Training group=10	Mean age = 73.2 years	At least Mild to moderate HL	HA	Customized Learning: Exercises for Aural Rehabilitation (clEAR)	Pre- and post-training assessments included speech-in-noise tests—the Build-a-Sentence Test (BAS) and the 4 alternative forced choice (4 AFC) test and the Client Oriented Scale of Improvement (COSI) questionnaire	+

Rao et al. (2017) [22]	To investigate the effects of hearing aid use and the effectiveness of ReadMyQuips (RMQ) on speech perception performance and auditory selective attention using electrophysiological measures.	Experimental study	N=22 1) Training group= 11 2) Control group=1 1	1) Training group (range = 60–85) 2) Control group (range = 49–85)	Mild to moderate HL	HA	Read My Quips (RMQ)	1. Cortical late event-related potentials (ERPs) 2. HINT sentences	+
Tye-Murray et al. (2017) [23]	This investigation was conducted to compare the efficacy of meaning-oriented auditory training when administered with a spaced versus massed practice schedule	Experimental study	N=47 1) Spaced group= 24 2) Massed group: 23	1) Spaced group: mean = 64.6 years 2) Massed group: mean = 69.6 years	HL (NS)	HA	Customized Learning: Exercises for Aural Rehabilitation (clEAR)	1. Transfer-Appropriate Processing (TAP) 2. The Build-a-Sentence test (BAS)	+
Yu et al. (2017) [24]	Clinical case study reports functional magnetic resonance imaging (fMRI) data from two hearing- impaired patients who were first-time HA users	Case report	N=2 1) Training group= 2 2) Control group= 0	1) 68 years 2) 52 years	Mild to severe HL	HA	Read My Quips (RMQ)	1. Multimodal Lexical Sentence Test for Adults (MLST-A) 2. Functional magnetic resonance imaging (fMRI)	+

Casserly et al. (2019) [25]	This study tested the viability of such popular media interviews as training materials, comparing their effectiveness to that obtained with sentence transcription training.	Experimental study	N=60, Training group= 60	Young adult	NH	None	A new set of AT materials: excerpts of interviews from popular media.	1. Speech recognition in quiet 2. Speech recognition in multi talker babble 3. High variability sentence recognition 4. Isolated word recognition with context	+
Jiam et al. (2019) [26]	To evaluate the impact of an online, short music training intervention on pitch and timbre perception in CI users	randomized controlled crossover	N=32 1) Training group= 15 2) Control group= 17	Aged 18 or over	HL (NS) and NH	CI	Online Music Training	1. Pitch task 2. Timbre task	+
Cardin et al. (2020) [27]	To test the effect of L-DOPA on the comprehension of a simulated cochlear implant acoustic signal in hearing individuals	Pilot study	N=35 Training group= NS	Age = 38.0 ± 10.1 SD)	(PTA average) Group 1: 16.4 ± 1.8, Group 2: 14.8 ± 1.3, Group 3: 14.3 ± 1.7	CI	Spectrally-Shifted Noise-Vocoded (SSNV) Speech Training	Spectrally shifted noise vocoded speech (SSNVS) in the presence of L-DOPA or a placebo	+
Kwak et al. (2020) [28]	To introduce the developmental process and contents of a healthcare mobile application-based aural rehabilitation tool, namely, Hearing	program development	N=44 1) Training group= 44 2) Control group= 0	Older adults (mean age= 72.89 years)	NH	None	Hearing Rehabilitation for Older Adults (HeRO) Healthcare Mobile	Phase 1: Development of E-Health Technology 1. Syllable Trainings Using Consonant–Vowel Combinations 2. Sentence Trainings under Background Noise and Fast Rate of Speech	+

Moberly et al. (2020) [29]	To demonstrate that a CAR approach incorporating auditory training (AT) by a speech-language pathologist (SLP) is feasible in adults receiving CIs and to explore whether this approach results in improved outcomes.	Pilot study	N=19 1) Training group= 6 2) Control training: i.Passive =7 ii.Active = 6	49-91 years	Moderate to profound SNHL	CI and HA (Teste d preoperat ively using their HA if worn)	Comprehesive Auditory Rehabilitation (CAR) Training	1. Speech recognition: i. AzBiosentences in quiet, ii. AzBiosentences in 10-talker babble, and iii. Consonant-Nucleus-Consonant (CNC) words in quiet 2. Self-reported QoL: i. Nijmegen Cochlear Implant Questionnaire ii. Hearing Handicap Inventory for Adults/Elderly iii. Speech, Spatial and Qualities of Hearing Scale	ND

NS: Not specified, NA: Not available, ND: No difference, HL: Hearing loss, NH: Normal hearing

Table 3: The acoustic complexity variables used in auditory training programs and the effectiveness trend

Acoustic complexity	**Variables**	**Studies that are found to use specific acoustic highlighting variables in auditory training programs**	**Findings on study effectiveness + (positive)/ ND (No differences)/ NA (Not Available)**		
		n (%) *Paper ID*	+	ND	NA
			n (%) *Paper ID*	n (%) *Paper ID*	n (%) *Paper ID*
Authenticity of sounds	Undegraded	16 (55.2) *1,2,4,6,11,13,14,15,16,17,18, 22,23,24, 25,26*	11 (68.8) *1,6,11,13,15,17,22,23,24,25,26*	3 (18.8) *4,14,18*	2 (12.5) *2,16*
	Degraded	13 (44.8) *3,4,5,7,8,9,12,14,19,21,25,27,28*	10 (76.9) *3,5,7,8,9,12,21,25,27,28*	3 (23.0) *4,14,19*	0 (0.0)
Background noise	Absence	18 (62.1) *1,2,6,7,9,12,13,14,16,17,19,23,24,25,26,27,28,29*	13 (72.2) *1,6,7,9,12,13,17,23,24,25,26,27,28*	3 (16.7) *14,19,29*	2 (11.1) *2,16*
	Presence	21 (72.4) *1,2,3,4,5,10,11,12,13,15,16,17,18,19,20,21,22,23,25,28,29*	15 (71.4) *1,3,5,10,11,12,13,15,17,20,21,22,23,25,28*	4 (19.0) *4,18,19,29*	2 (9.5) *2,16*
Complexity of utterances	Simple	5 (17.2) *8,9,23,24,25*	5 (100.0) *8,9,23,24,25*	0 (0.0)	0 (0.0)
	Complex	20 (69.0) *1,2,3,4,10,11,13,14,15,16,17,18,19,20,21,22,23,26,27,28*	14 (70.0) *1,3,10,11,13,15,17,20,21,22,23,26,27,28*	4 (20.0) *4,14,18,19*	2 (10.0) *2,16*
Distance	Close	5 (17.2) *8,12,15,24,25*	5 (100.0) *8,12,15,24,25*	0 (0.0)	0 (0.0)
	Distance	15 (51.7) *4,5,10,11,13,16,17,18,19,22,23,26,27,28,29*	10 (66.7) *5,10,11,13,17,22,23,26,27,28*	4 (26.7) *4,18,29*	1 (6.7) *16*
Learning Effect	New	9 (31.0) *1,4,12,13,15,16,19,24,25*	6 (66.7) *1,12,13,15,24,25*	2 (22.2) *4,19*	1 (11.0) *16*
	Adapted	20 (69.0) *1,2,3,5,6,7,8,9,11,14,17,18,20,21,22,23,26,27,28,29*	16 (80,0) *1,3,5,6,7,8,9,11,17,20,21,22,23,26,27,28*	3 (15.0) *14,18,29*	1 (5.0) *2*
Learning Style	Passive	7 (24.1) *1,5,10,12,13,15,24*	7 (100.0) *1,5,10,12,13,15,24*	0 (0.0)	0 (0.0)
	Active	26 (89.7) *1,2,3,4,5,6,7,8,9,10,11,12,13,14,16,17,18,19,20,22,23,25,26,27,28,29*	19 (73.0) *1,3,5,6,7,8,9,10,11,12,13,17,20,22,23,25,26,27,28*	5 (19.2) *4,14,18,19,29*	2 (7.7) *2,16*
Length of Utterance	Short	18 (62.1) *3,4,5,8,11,13,15,17,18,19,20,21,22,24,25,26,28,29*	14 (77.8) *3,5,8,11,13,15,17,20,21,22,24,25,26,28*	4 (22.2) *4,18,19,29*	0 (0.0)
	Long	15 (51.7) *2,3,4,5,9,10,12,13,14,16,22,23,27,28,29*	10 (66.7) *3,5,9,10,12,13,22,23,27,28*	3 (20.0) *4,14,29*	2 (13.3) *2,16*
Rate of utterances	Slow	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Individual/ normal conversation	17 (58.6) *2,3,4,5,8,13,14,16,18,19,22,23,24,25,26,27,28*	11 (64.7) *3,5,8,13,22,23,24,25,26,27,28*	4 (23.5) *4,14,18,19*	2 (11.8) *2,16*
Repetition	Once	14 (48.3) *3,5,7,8,9,16,18,19,21,24,25,26,27,28*	11 (78.6) *3,5,7,8,9,21,24,25,26,27,28*	2 (14.3) *18,19*	1 (7.1) *16*

	Repeated	13 (44.8) *2,4,6,7,10,11,12,13,14,15,17,22,23*	10 (76.9) *6,7,10,11,12,13,15,17,22,23*	2 (15.4) *4,14*	1 (7.7) *2*
Segmental	Little/no emphasis	4 (13.8) *6,7,8,26*	4 (100.0) *6,7,8,26*	0 (0.0)	0 (0.0)
	Emphasis	25 (86.2) *1,2,3,4,5,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,27,28,29*	18 (72.0) *1,3,5,9,10,11,12,13,15,17,20,21,22,23,24,25,27,28*	5 (20.0) *4,14,18,19,29*	2 (8.0) *2,16*
Set	Close	22 (75.9) *2,3,4,5,6,7,8,11,12,13,15,16,17,18,21,22,23,24,25,26,27,28*	18 (81.8) *3,5,6,7,8,11,12,13,15,17,21,22,23,24,25,26,27,28*	2 (9.1) *4,18*	2 (9.1) *2,16*
	Open	9 (31.0) *5,9,10,12,13,14,16,19,28*	6 (66.7) *5,9,10,12,13,28*	2 (22.2) *14,19*	1 (11.1) *16*
Sounds Origin	Live	2 (6.9) *23,29*	1 (50.0) *23*	1 (50.0) *29*	0 (0.0)
	Recorded	29 (100.0) *1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28, 29*	22 (75.9) *1,3,5,6,7,8,9,10,11,12,13,15,17,20,21,22,23,24,25,26,27 ,28*	5 (17.2) *4,14,18,19,29*	2 (6.9) *2,16*
Speaker Familiarity	Unfamiliar	20 (69.0) *1,2,3,4,5,9,11,12,13,14,15,16,18,19,22,23,24,25,27,28*	14 (70.0) *1,3,5,9,11,12,13,15,22,23,24,25,27,28*	4 (20.0) *4,14,18,19*	2 (10.0) *2,16*
	Familiar	9 (31.0) *4,5,6,7,8,9,12,21,26*	8 (88.9) *5,6,7,8,9,12,21,26*	1 (11.0) *4*	0 (0.0)
Stimulus Context	In-context	22 (75.9) *1,2,3,4,5,6,7,8,9,11,12,14,16,17,18,19,21,22,23,25,27,28*	16 (72.7) *1,3,5,6,7,8,9,11,12,17,21,22,23,25,27,28*	4 (18.2) *4,14,18,19*	2 (9.1) *2,16*
	Out-of-context	5 (17.2) *5,9,15,24,26*	5 (100.0) *5,9,15,24,26*	0 (0.0)	0 (0.0)
Stimulus Presentation	In sequence	9 (31.0) *5,6,7,8,14,15,19,22,25*	7 (77.8) *5,6,7,8,15,22,25*	2 (22.2) *14,19*	0 (0.0)
	Random	15 (51.7) *2,3,4,5,6,11,12,13,17,18,23,24,26,27,28*	12 (80.0) *3,5,6,11,12,13,17,23,24,26,27,28*	2 (13.3) *4,18*	1 (6.7) *2*
Suprasegmental	Little/no emphasis	15 (51.7) *4,9,10,16,17,18,19,20,21,22,23,24,25,27,29*	10 (66.7) *9,10,17,20,21,22,23,24,25,27*	4 (26.7) *4,18,19,29*	1 (6.7) *16*
	Emphasis	14 (48.3) *1,2,3,5,6,7,8,11,12,13,14,15,26,28*	12 (85.7) *1,3,5,6,7,8,11,12,13,15,26,28*	1 (7.1) *14*	1 (7.1) *2*
Target Position	Initial	8 (27.6) *2,3,9,10,16,18,21,27*	5 (62.5) *3,9,10,21,27*	1 (12.5) *18*	2 (25.0) *2,16*
	Middle	8 (27.6) *2,3,9,10,16,18,21,27*	5 (62.5) *3,9,10,21,27*	1 (12.5) *18*	2 (25.0) *2,16*
	End	9 (31.0) *2,3,9,10,16,18,21,23,27*	6 (66.7) *3,9,10,21,23,27*	1 (11.1) *18*	2 (22.2) *2,16*

frequently include Rate of Utterance—Slow (0%), Segmental—Little/No Emphasis (13.8%), and Sound Origin—Live (6.9%).

Interestingly, only 10 out of the 29 studies [Paper ID: 1, 2, 4, 5, 13, 14, 19, 23, 28, 29] incorporated both the least complex and most complex variables for at least one type of acoustic complexity. For example, for background noise complexity, the study included both the absence (least complex) and presence (most complex) variables in the auditory training. In contrast, the other studies included either only the least complex or only the most complex variables in their auditory training programs.

The effectiveness trends of auditory training programs that incorporate specific acoustic complexity variables

Overall, for each category of acoustic complexity, both the least complex and most complex variables demonstrated more than 50% positive findings when utilized. As illustrated in Table 3, several specific acoustic complexity variables were associated with effective outcomes in the studies. Notably, the following variables were associated with 100% positive outcomes in the studies:

- Complexity of Utterance - Simple
- Learning Style - Passive
- Distance - Close
- Segmental - Little or No Emphasis
- Stimulus Context - Out of Context

This trend highlights the acoustic complexity variables that consistently appeared in studies demonstrating effectiveness. The consistent positive findings across these variables indicate their potential importance in optimizing training outcomes for participants.

In contrast, certain acoustic complexity variables were associated with a high percentage of studies reporting no significant differences in outcomes. Specifically, the variables of Distance and Sound Origin (Live) yielded no difference results in 27% and 50% of studies, respectively. As these findings cannot imply a causal relationship, these findings should be interpreted with cautions.

DISCUSSION

The findings from this scoping review highlight the diverse landscape of adult auditory training programs, which cater to a broad age range and varying levels of hearing ability. The studies analyzed demonstrate that auditory training can enhance auditory skills among individuals with hearing loss (Dubno, 2013; Stacey et al., 2010; Casserly et al., 2019; Maren et al., 2019). Notably, the majority of studies (75.9%) indicated that these training programs are beneficial, underscoring the potential efficacy of auditory training interventions.

This trend emphasizes the positive impact that auditory training can have, yet it also reveals the necessity for further exploration into the variables that influence both successful and less favorable outcomes. The effectiveness of auditory training programs is closely linked to the acoustic complexity variables employed during training, which have been shown to affect training outcomes and participants' speech performance (Burk et al., 2006).

Adult auditory training programs available in literature

Based on the findings, the predominant type of auditory training program in the literature is computer-based auditory training (CBAT). While other studies also explored individual and group training with clinicians, Table 2 indicates that CBAT was the most widely used approach.

Preminger and Ziegler (2008) found that group training did not improve speech perception, as it was challenging to personalize training for individual needs. In contrast, CBAT allows for tailored training, enhancing its effectiveness.

The advantages of structured CBAT programs include flexibility, cost-efficiency, and easy accessibility, enabling users to train at home while clinicians monitor progress remotely (Henshaw et al., 2012). Consequently, CBAT programs are preferred for their adaptability to individual needs compared to other training methods.

Acoustic complexity variables used in adult auditory training programs

The study also explored the range of acoustic complexity variables used in these programs. The recorded sounds variable was the most frequently utilized, allowing for easier implementation and greater exposure to training stimuli compared to live sound presentations (Mendel & Owen, 2011). A comparison of performance between recorded and live sound presentation was conducted by Faulkner et al. (2012), who examined the perception of spectrally shifted noise-vocoded speech. In this study, participants were trained with both live and recorded speech, and the results suggested that training with recorded speech was as effective as live speech in improving spectrally shifted noise-vocoded speech perception. However, the researchers found that the recorded presentation allowed for greater exposure to training phrases than live sounds, which may have contributed to its effectiveness. Therefore, the recorded sound variable is preferable in auditory training, as it is easier to implement, more time-efficient, and provides greater exposure to training stimuli compared to live sound presentations.

The findings indicate that certain acoustic complexity variables were notably underutilized in the auditory training programs reviewed. Specifically, the Rate of Utterance—Slow was not employed in any of the studies, while Segmental—Little/No Emphasis was used in only 13.8% of them, and Sound Origin—Live was included in just 6.9% of the programs.

The low utilization of certain variables may indicate a preference for training methods that provide clearer and more structured environments, such as recorded sounds, which allow for better control over acoustic conditions. The lack of emphasis on a Slow Rate of Utterance suggests that researchers may not prioritize pacing adjustments, even though these adjustments are crucial for improving comprehension in individuals with hearing loss. Research has shown that a slower speech rate can reduce listening effort for individuals with cochlear implants (Winn & Teece, 2021). Therefore, adjusting the rate of speech is essential in training hearing-impaired individuals, allowing them to progress from tasks that require less listening effort (slow rate) to faster rates as they improve.

Moreover, the limited use of Segmental—Little/No Emphasis suggests that many studies focus on dynamic training approaches while potentially overlooking the benefits of incorporating less emphasis on specific phonetic elements in auditory training. Although previous research indicates that speech intelligibility improves for learners who receive segmental training followed by production-focused practice (Yenkimaleki & van Heuven, 2021), it is important to include the little/no emphasis variable. This addition can better mimic normal speech conversations, where emphasis on segmental elements is often absent. Similarly, the infrequent use of live sound presentations may highlight challenges in maintaining consistency and clarity in real-time training settings. Future auditory training programs should incorporate live voice and real-world listening scenarios, as these elements reflect more accurately the complexities of everyday communication.

In addition, only 10 out of the 29 studies [Paper ID:1, 2, 4, 5, 13, 14, 19, 23, 28, 29] incorporated both the least complex and most complex variables for at least one type of acoustic complexity. Future research should include a variety of acoustic complexity variables, ranging from least complex to most complex. The least complex variables may be beneficial for individuals who are just beginning their auditory training or those with significant hearing challenges. These simpler tasks can help build foundational skills without overwhelming participants. On the other hand, the most complex variables suggest that, as individuals progress, exposure to more challenging tasks can further enhance their auditory skills, preparing them for real-world listening situations. This approach can better prepare individuals with hearing loss to navigate real-world listening environments, ultimately enhancing their speech perception and communication skills.

Effectiveness of adult auditory training programs according to different use of acoustic complexity variables

The findings indicate that both the least complex and most complex acoustic complexity variables yielded over 50% positive outcomes across all categories. This suggests that a wide range of acoustic complexity can be effective in auditory training programs. The presence of positive results for both ends of the complexity spectrum highlights the adaptability of these training programs to different learning needs and contexts.

The results presented in Table 3 indicate that several acoustic complexity variables were linked to effective outcomes in the studies reviewed. Variables such as Complexity of Utterance - Simple, Learning Style - Passive, Distance - Close, Segmental - Little or No Emphasis, and Stimulus Context - Out of Context all achieved 100% positive outcomes.

While these findings are promising, it is important to note that they do not establish a causal relationship. The observed effectiveness may be influenced by various factors beyond the acoustic complexity variables themselves. For instance, participant characteristics, the specific design of the training programs, or external environmental factors could also contribute to the outcomes.

Despite this limitation, the consistent positive results associated with these variables suggest they play a significant role in enhancing the effectiveness of auditory training programs. This trend underscores the importance of incorporating these specific variables into training curricula to optimize participant outcomes.

For example, out-of-context stimulus has been used in a study by Loebach and Pisoni (2010) where the stimulus being transferred from meaningful sentences into semantically anomalous by replacing keywords with unrelated or out-of-context words. Their results show that participants trained with out-of-context sentences have more generalization compared to meaningful sentences. According to the findings, out-of-context sentences are more analytical in nature because they allow listeners to focus more on the acoustic elements of sounds as opposed to meaningful sentences, which force listeners into interpretive mode (synthetic approach).

Analytic training is a 'bottom-up' approach as it stresses on acoustic elements to receive the meaning of speech signals (Leo et al., 2012; Tye-Murray, 2009). Whereas synthetic training typically progresses from focusing on acoustic element recognition to understanding sentences. It is referred to as a 'top-down' approach because listeners must fill in the perceptual or acoustic gaps in the message by using their language knowledge and contextual understanding (Bentler et al., 2016). According to Leo et al., (2012), the recognition of acoustic elements of sounds enables listeners to have better understanding and comprehending words or sentences.

In contrast, certain acoustic complexity variables were associated with a high percentage of studies reporting no significant differences in outcomes. Specifically, the variables of Distance and Sound Origin (Live) showed no difference results in 27% and 50% of studies, respectively. Since these findings do not imply a causal relationship, they should be interpreted with caution. For instance, regarding Sound Origin (Live), only two studies utilized live voice, and of those, one reported no difference in effectiveness. Generalizing conclusions based on just two studies should be avoided.

Despite this negative trend, future research should incorporate these two variables (Distance and Sound Origin-Live), as they reflect real listening environments where sound may originate from a distance and from live sources. Including these variables could provide valuable insights into how individuals with hearing loss navigate complex auditory situations in everyday life.

STUDY LIMITATION AND RECOMMENDATION

Throughout this study, we identified various acoustic complexity variables used in auditory training programs that can influence effectiveness. However, certain limitations must be acknowledged. The effectiveness of these programs may also be impacted by other factors, such as the types of training, stimulus materials, and methods employed in the auditory training process. Therefore, future research should consider a comprehensive examination of all components of auditory training that may contribute to its overall effectiveness.

Additionally, our analysis was limited to the acoustic complexity variables reported in the studies reviewed. As a result, we may have overlooked other relevant variables that were not explicitly mentioned in the studies due to the brief descriptions of the auditory training programs provided by the authors. This limitation suggests the need for more detailed reporting in future studies to ensure a complete understanding of the factors influencing auditory training outcomes.

CONCLUSION

This scoping review demonstrates the influence of acoustic complexity variables on the effectiveness of adult auditory training programs, identifying key variables that are associated with positive outcomes. Future research should aim to incorporate a spectrum of acoustic complexities, from the least complex for beginners to the most complex for advanced learners, to provide a structured progression that enhances foundational skills and prepares individuals with hearing loss for real-world listening challenges. This approach may ultimately improve speech perception, communication skills, and overall satisfaction with auditory training outcomes.

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