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REVIEW ARTICLE

Listening Capacities Following Tailored, Self-guided Auditory Training: A Systematic Review

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Abstract

Background and Objective: Over the past decade, advancements in telehealth allowed for more accessible and tailored hearing care. As a result, an increasing number of home-based, self-guided auditory training programs emerged. Previous reviews on the efficacy of auditory training mostly covered both lab-based (i.e. clinician-guided) and home-based (i.e. self-guided) training programs. Therefore, the current study aims to review evidence on the efficacy of self-guided auditory training tools in hearing-impaired persons with hearing aids and/or cochlear implants and without sensory management.

Method: A systematic review was carried out using PubMed, Embase, Web of Science, and Scopus, covering publications up to January 2026. A quality assessment was conducted to evaluate the reliability of the evidence. Two authors independently reviewed publications.

Results: Twenty-eight eligible studies were identified, of which four contained a counselling module alongside the auditory training program. Fifteen studies allowed for tracking on-task improvements: they all reported improvements in the trained materials post-training. Concerning off-task (i.e. untrained) improvements, 14 out of 26 studies reported that the intervention group's speech-in-noise perception improved following training. Similarly, 5 out of 13 studies reported a self-perceived benefit in their communication after training.

Conclusion: The number of self-guided auditory training programs has increased markedly over the past years. Most studies reported good adherence, as evidenced by data logging, which is one of the key advantages of telehealth approaches. While the transfer to untrained tasks remains limited, all studies report improvements in the trained tasks, confirming that practice improves skills and abilities in persons with different auditory profiles.

Keywords: Systematic Review, Self-Guided Auditory Training, Speech Perception In Noise, Self-Report

List of Abbreviations

ALICE: Assistant for LIstening and Communication Enhancement; CI(s): cochlear implant(s); CV: consonant-vowel; EMA: ecological momentary assessment; ERP: event-related potential; FM: frequency modulation; GHAPB: Glasgow Hearing Aid Benefit Profile; GRADE: Grading of Recommendations Assessment, Development, and Evaluation; HA(s): hearing aid(s); HI: hearing impairment; HINT: hearing in noise test; HRQoL: Health-Related Quality of Life; LUISTER: LeUven Interactive Scheme for hearing Training Evaluation and audiological Rehabilitation; LACE: Listening And Communication Enhancement; M: mean; NSM: no sensory management; PRISMA: Preferred Reporting Items for Systematic reviews and Meta-Analyses; RCT: randomized controlled trial; SD: standard deviation; SiN: speech perception in noise; SNR: signal--to-noise ratio; SSQ: Speech, Spatial and Qualities of hearing scale; VC: vowel-consonant

Introduction

Hearing impairment (HI) is one of the most common health problems in the world. By 2050, nearly 2.5 billion people are expected to have some degree of hearing loss, and at least 700 million will require hearing rehabilitation [1]. Without appropriate follow-up, a person with HI will experience increased listening effort and difficulties with communication, learning, social-emotional functioning, employment, and quality of life [2].

Under the overarching term 'aural rehabilitation,' appropriate follow-up consists of four cornerstones: sensory management, knowledge, perceptual training, and counselling [3]. While such a multidisciplinary and holistic approach is recommended as best practice in hearing healthcare [4], many persons with HI do not have access to these four cornerstones. Sensory management, i.e., hearing aids (HAs), cochlear implants (CIs), or other assistive devices, is the most common and profitable cornerstone of aural rehabilitation and is accompanied by knowledge of how to use and clean them. However, providing counselling and perceptual training is expensive and mostly reserved for persons who receive CIs, as part of their rehabilitation program in the clinic. Auditory/perceptual training entails a series of exercises that are meant to help individuals differentiate sounds, practice speech understanding in noise, filter out background noise, learn to distinguish between different sounds and phonemes, enhance auditory and sequential memory and attention through focused listening tasks, improve processing speed, or integrate auditory and visual information, and enhance cognitive skills [5].

Counselling plays a crucial role in aural rehabilitation by addressing hearing loss's emotional, psychological, and social challenges [6,7]. Through counselling, clients better understand their hearing loss, set realistic expectations for their hearing devices, and develop strategies for effective communication [8].

Auditory training is often tailored to specific challenges and aims to transfer skills to improve daily life communication and build confidence [9, 10]. Sweetow & Palmer (2005) [11] were the first to perform a systematic review on potential improvement in communication skills through individual auditory training in adults with HI, including both experienced and new HA users. Evaluation of six studies that provided (clinician-led) training in the laboratory, yielded little evidence for the efficacy of individual auditory training, mainly due to methodological shortcomings.

At the turn of the century, software-based programs emerged, allowing for increased access to training and counselling more cost-effectively [12]. In 2013, Henshaw and Ferguson [13] published the first systematic review on the efficacy and quality of studies using (individual) computer-based auditory training, delivered in the laboratory ("lab-based") or conducted at the patient's home ("home-based"). The included study participants were adults with HI, both with and without sensory management (HA/CI users). The authors' evaluation did not result in recommendations regarding auditory training for clinical practice. The authors reported that the quality of many studies was insufficient (often due to lack of randomization, lack of transfer

to learning, limited compliance, and limited number of control groups). Additionally, only one study included cognitive outcomes despite strong connections between auditory processing and cognitive functioning. Lawrence et al. (2018) [14] later conducted a systematic review and meta-analysis on (individual) computer- and home-based auditory and cognitive training, to improve cognitive function. The included study participants were adults with HI, both with and without sensory management (HA/CI users). Of the nine included studies (five on auditory and four on cognitive training), results showed small but significant improvements in working memory and cognition for auditory training, while cognitive training led to small improvements in working memory and larger gains in overall cognition. However, the certainty of these effects was rated "low" for auditory and "very low" for cognitive training, highlighting the need for high-quality randomized controlled trials.

A subsequent state-of-the-art review evaluated 16 studies on the effect of (individual) computer-based auditory training in adults with HI, both with and without sensory management (only HA users), all with a comparison to a control group [15]. It was not specified whether the training was delivered in the lab or conducted at home. The authors concluded that auditory training can improve perception and other auditory cognitive skills, but that the results of studies were difficult to compare due to varying outcome measures and insufficient investigation into the long-term training benefits. A rapid review of studies published after 2013 reported on 11 (individual) lab-based and home-based auditory training studies that utilized some form of computer, handheld, or mobile device [16]. The included study participants were older adults (> 60 years) with HI, both with and without sensory management (only HA users). While some studies appeared methodologically stronger due to the recommendations of Henshaw and Ferguson [13], it remained difficult to draw solid conclusions on the efficacy of auditory training programs as a result of the variety of study designs, study quality, participant backgrounds, intervention approaches, and methods used to assess benefit.

While the abovementioned reviews adopted comprehensive inclusion criteria for study participants (i.e. HA/CI users as well as persons with HI without sensory management), the (systematic) reviews of Cambridge and colleagues (2022) [17], Dornhoffer and colleagues (2024, 2025) [18,19], and Tamati and colleagues (2025) [20] specifically focused on the efficacy of (individual) lab-based or home-based auditory training in post-lingually deafened adult CI users. Cambridge and colleagues (2022) [17] analyzed 10 studies published after 2010 and concluded that there is a need for high-quality studies to determine which of the auditory training methods are most effective for specific auditory outcomes in adults with CIs. Only one study was a randomized control trial; only four had a control group. None of the studies reported power calculations nor blinding for examiners and participants. The more recent systematic review and meta-analysis by Dornhoffer and colleagues (2024) [18] included 23 studies, of which 13 did not have a control group. Although only a few studies had limited evidence and external validity, the authors concluded that auditory training can improve speech recognition in adult CI participants. In 2025, Dornhoffer and colleagues reviewed their own studies on auditory training in >100 adult CI recipients during the first year of post-activation [19]. Compared to CI users who did not train or used other resources, those with auditory training demonstrated earlier gains in speech recognition and a higher improvement in functional abilities (as measured by the Cochlear Implant Quality of Life-35). Lastly, Tamati and colleagues (2025) [20] reviewed the evidence on demographic, auditory, cognitive-linguistic, and psychosocial factors that influence responsiveness to auditory training in CI users. This influence appears to be well documented for speech perception outcomes, and the authors conclude that CI users' responses to auditory training can be predicted by a set of shared as well as unique factors. Since this influence has been described much less beyond traditional speech recognition measures, the authors also emphasize the need to expand outcome assessments to real-world communication and social functioning.

The systematic reviews mentioned above mostly examined both lab-based and home-based auditory training programs. The majority of lab-based training programs are actively guided by a clinician, whereas home-based programs are mainly self-guided. However, practicing with a self-guided program does not imply that a clinician should not monitor progress. Advancements in telehealth are increasing access to fully self-guided training programs.

Telehealth, which involves providing services through computers, smartphones, and the internet, has emerged as an accessible and tailored approach to hearing care [21-23]. Telehealth allows for continuous monitoring of hearing devices, aural rehabilitation, and performance outcomes. The COVID-19 pandemic has highlighted the importance of remote treatment options, making self-guided auditory training a practical solution for those seeking to practice and refine their listening skills at their own pace.

Self-guided auditory training shows potential for improving communication difficulties, but a thorough review of existing evidence is needed to evaluate its efficacy for different populations. The current study reviews the studies on auditory training that do not involve a clinician during training (i.e. self-guided), or at most to monitor progress. We ask whether evidence exists to enhance daily-life listening and the ability to manage difficult listening situations through tailored, software-based auditory training in adults with (self-reported) hearing impairment. The auditory training must be self-guided, individual, and self-explanatory, and presented via software at home or elsewhere. The software can include counselling materials alongside the auditory training module.

Improving everyday listening and navigating challenging listening environments requires improvements to trained tasks and transfer towards untrained tasks. Henshaw and Ferguson (2013) [13] defined real-life benefits as improvements in functional speech intelligibility in noise and enhancements in cognitive skills. Additionally, real-life benefits also encompass reduced listening effort, which can be assessed through self-reports or objective measures. Accordingly, we reviewed study characteristics related to methodology and stimuli, task improvements, and the potential for generalization to untrained tasks, and we evaluated their methodological rigor and potential biases. The studies examined include training programs designed for individuals with HAs and/or CIs (with different levels of experience), and those who do not wear assistive devices (no sensory management). While these groups have different auditory profiles and rehabilitation needs, and may respond differently to auditory training, our review aimed to evaluate the overall efficacy of self-guided auditory training interventions, irrespective of the specific hearing device or lack thereof. Nonetheless, relevant differences in training approach and outcome between these populations are mentioned and discussed. Ethical approval was granted by the Federal Agency for Medicines and Health Products (Eudamed number: CIV-22-06-039801-SM03).

Methodology

Search Strategy

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) checklist was followed to perform the systematic review. This systematic review was prospectively registered on PROSPERO (ID: CRD42023466747). Search terms included (("Listening difficult*" OR "hearing impairment" OR "hearing aid" OR "hearing device" OR "hearing instrument" OR "cochlear implant" OR "self-reported hearing loss") AND ("auditory training" OR "auditory learning" OR "counseling" OR "counseling" OR "e-learning" OR "perceptual training" OR "perceptual learning") AND “adult”). Key terms were systematically searched in online databases MEDLINE (PubMed Interface), EMBASE (embase.com interface), ScienceDirect, Web of Science, and APA PsycNet (PsycINFO). The articles included were limited to adult participants and were reported in the English language. The review process was managed using the web-based collaboration software platform Covidence [24,25].

Before the completion of the systematic review, a second literature search was conducted in PubMed using the same search string to include recent publications that met the eligibility criteria. Two additional studies published in 2025 were included.

Study Selection

Studies were included in the systematic review if a) an auditory training program, whether or not combined with a counselling

module, was prospectively evaluated, b) the auditory training program focused on enhancing the participant's listening performance, c) the auditory training program was self-guided (except for monitoring progress), d) primary outcomes were measured with standardized tests, and d) a comparator control was included. The latter was chosen to ensure consistency in quality assessment and avoid penalizing studies solely based on design type. Studies were excluded if they did not include a control group, only involved counselling, included children as participants, focused on tinnitus management, were not peer-reviewed, and were unavailable in English. All articles were screened independently by two authors to determine the final studies for inclusion. Disagreements were resolved through discussion.

Data Extraction

The data extracted from each study included the study details, training characteristics, and outcome measures. Study details include authors, year of publication, sample size, and participant characteristics. The training characteristics were the stimuli used during training (e.g., words, sentences, music), training duration, frequency, and modality (e.g., online, DVD…). Outcome measures included adherence, on-task improvements (i.e. improvements in trained tasks), off-task improvements (i.e. improvements in tasks/materials that were not directly trained), self-report measures, and retention of training benefits.

Quality of Evidence

Following Henshaw and Ferguson (2013) [13], the quality and potential sources of bias of the studies were assessed using the 2004 Grading of Recommendations Assessment, Development, and Evaluation (GRADE) guidelines [26]. Each measure was assigned a score of 0,1, or 2. A score of 0 indicates flawed or no information from which to make a judgment, 1 indicates weak information or lack of detail, and 2 indicates appropriate use and reporting. Two authors rated the studies independently.

The scientific study quality and potential sources of bias were assessed using five independent measures: randomized allocation of participants, inclusion of control group(s), sample size and power calculation, blinding, and outcome measure reporting. Five additional measures aimed to capture the quality of the intervention study designs: outcome measure selection (generalization to other non-trained tasks), training feedback (which has been shown to maximize auditory learning in auditory training), the assessment of self-reported benefits (questionnaires), reporting of training compliance/adherence, and long-term follow-up (to assess retention of training effects). An overview of these measures and the score allocation can be consulted in Table 1.

Individual measure scores were summed to form an overall quality score that was then used to inform the level of evidence attributed to each study. Study quality scores ranging from 0-5 were labeled as very low levels of evidence, indicating that the effect of estimation is uncertain. Scores ranging from 6-10 indicate a low level of evidence, reflecting that further evidence is very likely to impact our confidence in the estimation effect and is expected to change the estimate. Scores of 11-15 have a moderate level of impact, where further evidence is expected to impact our confidence in the estimation and may change the estimate. Scores of 16-20 indicate a high level of proof, where further evidence is unlikely to change our confidence in the effect estimation.

Results

In total, 3965 abstracts were systematically screened in online databases (Figure 1). One hundred eighty-three studies were retrieved for full-text evaluation. One hundred fifty-five studies were excluded as they were not self-guided (51), not a prospective survey of auditory training (26), used non-normative outcome measures (14), were review articles (16), proposals of studies (7), did not have a comparator control (7), included group therapy (6), included children as participants (2), were directed to improve tinnitus symptoms (1), no full text (10) or English text available (8), merely a clinical case (6), or only involved counselling (1).

Table 1: Overview of the quality measures and the associated scoring system (cf. GRADE guidelines) used for the quality assessment of included studies.

Measures for scientific study quality and potential sources of bias			
Measure	0	1	2
Randomized allocation of participants	Participants were not randomly assigned to intervention and control group(s).	/	Participants were randomly assigned to intervention and control group(s).
Inclusion of control group(s)	/	Only a passive control group was included.	An active and passive control group was included.
Sample size and power calculation	The sample size was small and no power calculation was included.	The sample size was large, but no power calculation was included.	The sample size was large and a power calculation was included.
Blinding	Neither the participants nor the experimenter were blinded.	Only the experimenter or the participants were blinded.	Both the participants and the experimenter were blinded.
Outcome measure reporting	/	Selective reporting of data.	Complete reporting of data.
Additional measures for the quality of the intervention study designs			
Measure	*0*	*1*	*2*
Outcome measure selection: generalization to non-trained tasks	No off-task outcome measure was included.	Only one off-task outcome measure was included.	More than one off-task outcome measure was included.
Training feedback	No training feedback was provided.	/	Training feedback was provided.
Assessment of self-reported benefits (questionnaires)	No self-report measures were included.	/	At least one self-report measure was included.
Reporting of training compliance/adherence	Compliance/adherence was not monitored or reported.	Compliance/adherence was measured by self-report, or only drop-outs were mentioned.	Compliance/adherence was objectively measured and reported.
Long-term follow-up	Retention of training effects were not measured.	/	Retention of training effects were measured.

Study Characteristics

Twenty-eight studies involving 1380 participants met the inclusion criteria. Participants were typically older adults (M=63.80, sd=7.76) with mild to severe hearing loss with or without HAs or CIs. Intervention and sample sizes ranged from 18 to 279 participants (M=38.67, SD=50.81, median = 33.5). Although definitions differ between studies, most studies described themselves as auditory training [9,27-44]. Three studies presented themselves as auditory-cognitive training [45-47], one as competing talker training [48]. Other training studies included auditory perceptual training [49] and audio-motor perceptual training [50]. One study used auditory training in combination with communication strategies and/or an FM system [41].

Ten studies assessed the efficacy of training for HA users [30,32,35,37,40,42,43,47,49,51], seven studies for CI users [28,33,36,38,39,52,53] and eleven studies assessed the efficacy in listeners without sensory management [9,27,29,31,34,41,44-46,48,50]. Van Wilderode et al. (2025) [48] also included a few HA users, and van Wieringen et al. (2025) [42] also included a few CI users.

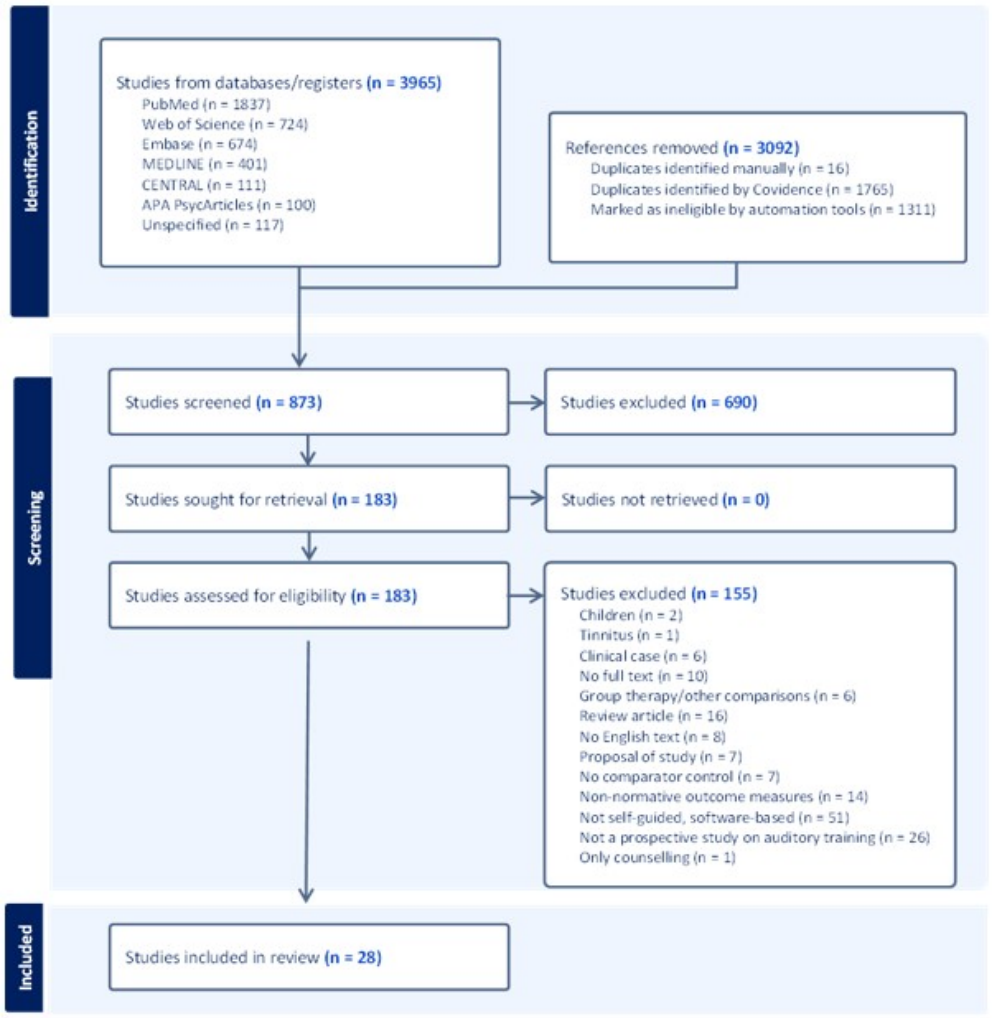

Figure 1: Flowchart of the study selection process, according to PRISMA guidelines.

Quality of Evidence

Overall study quality ranged from low (11/28), moderate (13/28), to high (4/28), as shown in Table 2.

Scientific study quality. Out of a maximum of 10 points, one study achieved 10 points [36]. The study randomized participants, used a passive and an active control group, an appropriate power calculation, blinded participants, and reported all outcome measures. Only 4/28 studies used blinding of either participants or experimenters [32,33,36,50]. Four studies did not randomize groups [30,35,46,47]. Twenty out of 28 studies did not report a power calculation for an appropriate sample size [9,27,29,30,32-38,40,44-46,49-53] .

With regard to the quality of the intervention study designs, all 28 studies reported on the outcome measure selection and assessed transfer to untrained measures. Five studies only used one outcome measure to assess the transfer of learning to untrained tasks [27,30,39,52,53].

Table 2: Scores for scientific and training-specific validity criteria and corresponding levels of evidence for the included studies, adapted from GRADE Working Group (2004).

	Scientific study validity criteria					Training-specific study validity criteria					Overall quality score	Level of evidence
Study	Randomi-zation	Control group	Power calculation	Blinding	Outcome measure reporting	Outcome measure selection (generalization)	Training feedback	Self-report	Reportingcompliance	Follow-up		
Stecker et al. (2006) [49]	2	1	0	0	2	2	2	0	0	2	11	Moderate
Sweetow Sabes (2006) [9]	1	1	0	0	1	2	2	2	1	0	10	Low
Anderson et al. (2013) [45]	2	1	0	0	2	2	0	0	0	0	7	Low
Olson et al. (2013) [37]	2	1	0	0	2	2	2	2	1	0	12	Moderate
Humes et al. (2014) [31]	2	1	2	0	2	2	2	2	2	2	17	High
Ferguson et al. (2014) [29]	2	1	0	0	2	2	2	0	0	0	9	Low
Karawani et al. (2016) [34]	2	2	0	0	1	2	2	0	2	0	11	Moderate
Abrams et al. (2015) [27]	2	1	0	0	2	1	0	0	2	0	7	Low
Schumann et al. (2015) [53]	2	1	0	0	2	1	2	0	1	2	11	Moderate
Rishiq et al. (2016) [40]	2	1	0	0	2	2	0	0	1	0	8	Low
Saunders et al. (2016) [51]	2	2	0	0	2	2	0	2	1	2	13	Moderate
Ihler et al. (2017) [33]	2	1	0	2	2	2	0	2	1	0	12	Moderate
Rao et al. (2017) [47]	0	1	2	0	2	2	0	0	2	0	9	Low
Whitton et al. (2017) [50]	2	1	0	2	2	2	2	0	1	0	12	Moderate
Yu et al. (2017) [44]	2	1	0	0	2	2	2	0	0	2	11	Low
Saunders et al. (2018) [41]	2	1	2	0	2	2	2	2	2	0	15	Moderate
Humes et al. (2019) [32]	2	2	0	0	2	2	0	0	0	0	8	Low

Jiam et al. (2019) [52]	2	2	1	1	2	2	2	2	2	2	18	High
Chari et al. (2020) [28]	2	1	2	0	2	1	2	2	2	0	14	Moderate
Reis et al. (2021) [38]	2	1	0	0	2	2	2	2	2	2	15	Moderate
Reynard et al. (2022) [39]	2	1	0	0	2	1	2	0	2	2	12	Moderate
Magits et al. (2023) [36]	2	2	2	2	2	2	2	2	2	2	20	High
Lai et al. (2023) [46]	0	2	0	0	2	2	2	0	2	0	10	Low
Van Wilderode et al. (2023) [43]	2	1	2	0	2	2	2	2	2	0	15	Moderate
Han et al. (2024) [30]	0	1	0	0	2	1	2	2	2	0	10	Low
Koprowska et al. (2024) [35]	0	1	0	0	2	2	2	0	0	0	7	Low
Van Wilderode et al. (2025) [48]	2	2	2	1	2	2	0	2	2	2	17	High
van Wieringen et al. (2025) [42]	2	1	2	0	2	2	2	2	2	0	15	Moderate

Most studies mentioned that feedback was provided (20/28), and 14/28 studies used (a variety of) self-reported questionnaires. Definitions of adherence varied. For example, some studies reported this as the number of drop-outs (e.g., Sweetow & Sabes (2006) [9]) or as mean time practiced (e.g., Rishiq et al. (2016) [40]), which could be influenced by outliers. Other studies used self-reported adherence (e.g., Abrams et al. (2015) [27], Olson et al. [37]), which could be an overestimation of compliance. Only 10 out of 28 studies reported a follow-up of the training benefits, ranging from 2 weeks [44] to 8.5 months [32].

Stimuli used in training

The 28 studies in the systematic review employed a variety of stimuli, including words, sentences, and stories, throughout the training process (see Table 3 for a detailed overview and Table 4 for a synthesis). Some studies designed passages [34], words [32], syllables [49,53], phonemes [29,44], or competing talkers [48]. Most of these stimuli were implemented in the training programs of CI or HA users as well as HI listeners without sensory management. Alternative approaches explore music perception or melodic contours in CI users [28,52]. The LACE paradigm integrates counselling components and communication strategies alongside auditory stimuli in HI listeners without sensory management [9,46] and in HA users [37]. Similarly, the ALICE app contains a separate counselling module, which regularly prompts the participant to answer questions about their listening experience and difficulties, and then provides tailored tips and advice [42]. The ReadMyQuips program employs audiovisual crossword puzzles presented in background noise in HA users [40].

Table 3: Detailed overview of the included studies.

Study	Comparator	Participants	Stimuli training	Frequency and adherence	On-task improvements	Off-task training improvements	Self-reported benefits	Retention
Stecker et al.(2006)[49]	RCT with a cross-over design	*New and experienced HA users*Immediate training: N=12, M age=69 Delayed training: N=11, M age=69	*Consonant-vowel and vowel-consonant syllables*	35-70 min/day, 5x/week for 8 weeks*Adherence not mentioned*	Improved syllable scores	The training group showed improved phoneme recognition in untrained voices.No SiN improvement (limited power)		Syllable benefits persist after 8 weeks.
* *Sweetow Sabes (2006)*[9]	RCT with a cross-over design	*Adults with hearing impairment, no sensory management*Training: N=38 (+ 16 drop out), M age=63.15 Control N=27 (+ 6 drop out), M age=64.2	LACE:*speech in babble noise, time-compressed speech, competing speaker, auditory working memory, missing word, interactive communication strategies (counseling)*	30 min/day, 5x/week for 4 weeks*Drop-outs mentioned, adherence not mentioned*	Significant improvements on all trained tasks	The training group showed improvement with QuickSIN, increased average listening span and improved Stroop performance. No improvement with the hearing in noise test.	Improvement on hearing handicap inventory and on the communication scale for older adults after training	
* *Anderson et al. (2013)*[45]	Partial RCT (stratified) with an active control:*(Educational DVDs and completed multiple-choice questions about the content)*	*Older adults with hearing impairment, no sensory management*Total N=58Training: N=29, M age=64.11 (5.78) Active control: N=29, M age=64.07 (5.22)	Brain Fitness™ cognitive training: *Time-order judgments of frequency-modulated sweeps, discrimination of confusable syllables, recognizing sequences of syllables and words, matching pairs of confusable syllables and words, implementing sequences of commands, and answering questions from stories*	1h/day, 5x/week, for 8 weeks*Adherence not mentioned*		The training group showed a reduction in envelope coding, but not for temporal fine structure.The hearing-impaired group showed improved speech-in-noise, and the normal hearing group showed improved memory. Both groups showed improved attention.		
* *Olson et al. (2013)*[37]	Partial RCT (stratified) with a passive control	*New (<6m) and experienced (>2y) bilateral HA users*training: N=8 (new), M age=66 (9.6); N=14 (experienced), M age=68 (6.9) Control: N=7.0, M age=66 (9.6)	LACE DVD*speech in babble noise, time-compressed speech, competing speaker, auditory working memory, missing word, interactive communication strategies (counseling)*	10 sessions (2x same) during 2 weeks (total training time 4 weeks)*Self-reported adherence: 94% -98.5%*		Improved sentence recognition (larger benefit for new HA users), no improved compressed speech for all groups. The training group showed improved competing talker intelligibility	Effect of training: new HA users reported a larger overall benefit, an improvement on the qualities section of SSQ when controlled for speech subscale	
Ferguson et al. (2014)[29]	RCT, quasi-crossover design with delayed training	*Adults with a hearing impairment, no sensory management*Total: M age=65 Immediate training: N=23, Delayed training: N=21	*Eleven phoneme continua, a three-interval, three-alternative, forced choice oddball paradigm. Exercises were presented on the*IHR-STAR *platform.*	15 min/day, 6x/week for 4 weeks*82-87% performed the recommended training*	Improved phoneme discrimination	There were no significant improvements in SiN. The training group showed improved working memory and divided attention. No significant improvements during the delay phase	Improved Glasgow hearing aid benefit profile (overall disability index) for the training groupNo significant improvement in SSQ	Improvements retained for at least 1 month
Humes et al. (2014)[31]	RCT with a passive control	*Adults with a hearing impairment, no sensory management*Total N=55Intervention: N=16Passive control: N=20Active control: N=19	*Frequent words and phrases; recording of selected sentences from the Veterans Administration Sentence Test (VAST); the Auditec recording of CID Everyday sentences; closed-set Hagerman-format sentences*	75-190min/day, 2x/week or 3x/week for a total of 15 sessions *Adherence not mentioned*	Improvements on Hagerman-Format sentences in ICRA noise	No significant improvements to untrained speakers of SiN.		
Karawani et al. (2016)[34]	RCT, quasi-crossover design: immediate training, delayed training and no training	*Normal hearing or hearing impairment, no sensory management*Total N=35.Immediate training: N=14, M age=66 (3.1) Delayed training N=11, M age=69 (2.5) No training: N=10, M age=67.6 (4.4)	*Thematic passages of 3–6 min in Hebrew, read by five readers with MPC questions. Stories are presented in time-compressed speech, speech in noise and competing talker*	20-30min/day, 13 sessions over 4 weeks*Good adherence: 41/46 completed all 13 sessions, 5 completed 10-11 sessions*	Improvements in SiN, time-compressed speech and competing speaker conditions	No improved sentences in noise, no transfer toward more basic psychophysical tasks (duration or frequency discrimination)Training and active control showed a small improvement on the pseudoword task		
Abrams et al. (2015)[27]	RCT with a passive control *(Only hearing aids)*	*Adults with hearing impairment, no sensory management*Training: N=15, M age= 65.6 (5.53) PC: N=14, M age=61.8 (8.43)	Read My Quips and hearing aid fitting*Audiovisual (A/V) training program delivered through the use of games, puzzles, and videos*	30 min/day, 5x/week for 3 weeks*On average, self-reported adherence was 4.5h trained out of the recommended 7.5h*		Improved speech-in-noise and words in noise for all groups		
* *Schumann et al. (2015)*[53]	RCT with a passive control	*CI users (>2 y experience)*Intervention N=15, M age=60 PC: N=12, M age=61.0	*nonsense-syllable combinations (VCV and CVC)*	54-60min/day, 2x/week for 3 weeks*Good adherence*	significant improvement on vowel and consonant identification (dependent of the stimulus)	Speech-in-noise improvements for the training group		Improved speech-in-noise remained after 6 months

Rishiq et al. (2016)[40]	RCT with a passive control	*HA users*Training: N=12, M age=68 (8.4) PC: N=12, M age=69.9 (10.5)	ReadMyQuips*A modified crossword puzzle consisting of witty quips designed to engage the user during training.*	30 min/day? 5x/week for 4 weeks*Good self-reported adherence. Mean time spent on training = 956.57min (SD = 226.69).*		No significant improvements in auditory-only or auditory-visual speech performance		
Saunders et al. (2016)[51]	RCT with an active control and passive control*(AC1: stimuli: listening to books stored on a laptop) stimuli PC: one-on-one educational counseling session (30 min)*	*veterans with HAs (experienced or new)***LACE DVD:** New: N = 33, M age= 67.6 (7.4)Exp: N = 35, M age= 68.9 (8.1)**LACE computer:** New HA: N = 32, M age= 68.7 (8.1)Exp HA: N = 33, M age= 69.3 (7.7)**Placebo**: New HA: N = 32, M age= 66.7 (7.6)Exp HA: N = 41, M age= 67.4 (7.8)**Passive control**: New HA: N = 39, M age= 71.0 (7.5)Exp HA: N = 34, M age= 68.9 (6.9)	LACE DVD and LACE computer*Listening to degraded speech (SiN, rapid speech, competing speakers) and two tasks aim to improve cognitive processes related to auditory memory (word memory task) and the use of linguistic and contextual cues in the speech recognition process (missing word task). Counselling about listening strategies)*	LACE DVD: 30min/day, for 10 sessions in 2 weeks*Self-reported compliance: 85%*LACE computer: 30min/day over 4 weeks*Self-reported compliance:84%*	LACE-computer group showed improvements on SiN, compression on rapid speech, competing speaker task and word memory training and use of linguistic content	No improvements on word understanding in noise, rapid speech, competing talker, word memory, use of linguistic context, no significant effect on digit span	The training group:No significant differences in the Abbreviated profile of Hearing aid benefit and hearing handicap inventory	Not retained
** Ihler et al. (2017)*[33]	RCT with an active control*(Stimuli: unfiltered training)*	*Experienced CI users (>6m)*Total: N=20. Intervention: N=10, M age=58.8 (9.0) Control N=10, M age=55.2 (9.8)	Heidelberg training CD – telephone specific filtered*64 minutes of speech material with different levels of difficulties, including words, poems and short stories*	15 min/day, 10-14 weeks of practice*Self-reported adherence of 19.9h (+-21.9) hours*		No improvements on the monosyllabic test, only improvements for filtered version	no statistics on the Abbreviated profile of Hearing aid benefit data	
** Rao et al. (2017)*[47]	Partial RCT with an active control*(Stimuli: Audiobooks)*	*New HA-users* Training N=11, M age=69 (7.3) AC: N=11, M age=65 (8.9)	Computer version of ReadMyQuips*Audiovisual crossword puzzles comprising quips or witty expressions in the presence of background noise*	30 min/day, 5x/week for 4 weeks*Average time spent M=945 (SD=195) minGood adherence*		Improved (behavioral) selective attention for all groups. Training group showed improved SiN and auditory evoked response measures		
** Whitton et al. (2017)*[50]	RCT with an active control*working memory capacity training*	*Older adults with hearing impairment, no sensory management*Total N=24, M age=70.Training: N=13. M age=65.45 (4.1) Control N=11, M age=66.57 (4.47))	Computerized closed-loop sensorimotor interfaces (action video games and musical instruments) discriminate subtle *variations in sound level, frequency or modulation rate of tone pips or spectrotemporal modulated noise presented in a background of speech babble.*	3.5h/week for 8 weeks*6 drop-outs after baseline*	Increased speech babble levels (decreased signal-to-noise ratio)	No improvement on isolated words at difficult signal-to-noise ratios, no improved frequency discrimination thresholds, working memory capacity or inhibitory control.The training group showed improved SiN (words and sentences)		
**Yu et al. (2017)*[44]	RCT with a passive control*Traditional AT in clinic*	*Older adults with hearing impairment, no sensory management*Training: N=10, M age=75.4 PC: N=10, M age= 75,8	10 Korean consonants followed by /a/ vowel resulting in 10 nonsense tokens	40min/day, 6x/week, 4 weeks*Adherence not mentioned*		No improved vowel scores, training group showed improved scores on consonant and sentence tests		Retention remained after 2 weeks
Saunders et al. (2018)[41]	RCT Group 1: CSSGroup 2: FM+CSSGroup 3: FM + counselling + AT	*Blast-exposed veterans with normal hearing who reported functional hearing difficulties. No sensory management*Group 1: N=25, M age=33.7 (8.0)group 2: N=25. M age=34.4 (7.8) Group 3: N=25, M age = 33.9 (7.7)	Brain fitness program *auditory pattern recognition, gap detection, memory and sound discrimination,*	8 weeks *Overall adherence: extremely poor (only 8.1% performed recommended training sessions, 12% drop-outHighest attrition in AT+CSS groupCSS: 48% reported using suggestionsFM-system: good adherence*		Improved speech-in-noise (FM+CSS+AT and FM+CSS group more than AT+CSS); The AT+CSS+FM showed larger improvements for gap detection (possibly regression to the mean)	Use of a FM system, combined with auditory training with compensatory communication strategies provided self-reported cognitive benefits	
Humes et al. (2019)[32]	Partial RCT (stratified) with an active and passive control*(Active control: audiobooks in quiet with questions)*	*HA users*Total: N=45.Intervention: N=15, M age= 71.9 (6.1) Active control: N=15, M age= 71.3 (7.5) Passive Control: N=15, M age= 72 (7.1)	*Words, phrases and sentences in background noise and trial-to-trial feedback4 different talkers*	3x 90-120 min/week for 5 weeks*Good adherence: 12/13 performed all sessions*	Better performance at session 2	No improvements in SiN	No significant improvements on the hearing handicap inventory for the elderly;Increased satisfaction with HA at session 2	Improvement on trained materials was maintained after 8.5 months
Jiam et al. (2019)[52]	RCT: cross-over with an active control*(non-musical audiobook listening)*	*Normal-hearing and CI-users*Training: N=8 NH + 8 CI, M age of NH= 37 (16), M age of CI = 63 (13) Control: N=9 NH + 7 CI, M age of NH= 37 (16), mean age of CI: 63 (13)	Meludia (self-paced music training program):*Musical exercises, including micro-melody, melodic patterns, pitch direction, pitch identification, density.*	Minimum 2h/week, for 4 weeks *11 participants did not meet minimum requirement of 2h per week of music training*		Small improvements in pitch discrimination and timbre discrimination for all groupsThe training group showed slightly greater benefit for music instrument identification (procedural learning).		

Chari et al., (2020)[28]	Prospective cohort study with an active and a passive control*Angelsound: melodic contour exercises with varying difficulty (only auditory)*	*Post lingually deafened CI users, 18+ (>1y CI)*Intervention N=7, M age=61 AC N=7, M age=61 PC: N=4, M age=63	Contours program:*melodic contour patterns performed on a keyboard: visual, auditory and motor cues*	30 min/day, 5x/week for 1 month (total of 10 training hours)*was logged, not reported*		Training and active control showed improvements for melodic contour identification (smaller improvement for active control)No improvements in word discrimination in quiet, speech-in-noise, emotion recognition, pitch discrimination		
Reis et al. (2021)[38]	RCT with a cross-over design using visual training as a control*(Visual training: initial/final consonant identification, sentence recognition)*	*CI users (>1y)*AT: N=16VT: N=15	Auditory training:*Sentences and words: consonant identification, sentence recognition and final consonant discrimination (SNR ranging from + 20 to -16 dB SNR in babble noise)*	5x/week, for 6 weeks*70.8% completed 30 or more sessions, 6 (25%) completedbetween 26 and 29 sessions, and 1 (4.1%) completed20 sessions. Four participants withdrew*	Improved SNR, initial/final consonant and sentence perception	No improved speech-in-noise perception, no improvement on attention, inhibitionno clear improvements in outcomes measured beyond the trainingSignificant improvement of quality of life was not retained	Auditory training: Improved quality of life. All groups: no improvement on self-report measures of listening, communication apprehension, and self-efficacy	Improvement of quality of life was not sustained after 4 weeks, retention, word recognition improvements declined
* *Reynard et al. (2022)*[39]	RCT with a passive control	*CI users (>9m)*Training: N=15, Mage =48 (24-76)PC: N=15, M age=60 (45-75)	serious game scenario: *detecting and discriminating target sounds in noise, target sound identification and syllable and word-based games*	20 training sessions during 5 weeks*2 did not perform the training87% completed training*		The training group showed improvements in speech-in-noise		Training:Improvements retained, but smaller
Magits et al. (2023)[36]	RCT active control*(Stimuli: AM detection, frequency modulation, a music scale, detection of gaps in noise bands, speech stimuli in quiet, read a text)*	*CI users (experienced and new users)*Total: N=40. M age=63.1 (8.4) Intervention: N=20,Control: N=20	LUISTER: *five training modules with different analytic and synthetic tasks: vowel and consonant identification, themes, identifying the gender of voice, and emphasis on words, clock reading and completing sentencesall exercises in silence, speech weighted noise and babble noise*	15-20 min/day, 5x/week, for 16 weeks*Good adherence: 1 performed less than recommended training time*	All groups improved on digits in noise perception and phoneme identification, the training group showed decreased SNR-level throughout training	The training and active control group show an improvement in speech-in-noise No improvements in inhibition, task switching or working memory updating	Improved hearing related quality of life for the training group and the active control	All groups: SiN and hearing related quality of life improvements were maintained after 8m
* *Lai et al. (2023)*[46]	Partial RCT (stratified): active and passive control*(Stimuli AC: audio clips with MPC)*	*Adults with mild hearing impairment, no sensory management*Training N=20, M age=66.7 (4.6) AC: N= 21, M age=66.2 (4.6) PC N= 23, M age=67.26 (6.11)	LACE*speech in noise, rapid speech task, competing speaker task, word memory task*	30 min/day, 11 sessions over 15 days*Good adherence: All assessments were completed*	Improvements on SiN and auditory memory	Improvements in speech-in-noise for the training group.No improvements in short-term memory and attention		
* *Van Wilderode et al. (2023)*[43]	Partial RCT (stratified) with a passive control	*Experienced hearing aid users*Total N=40Intervention N=20, M age=69.0 (6.5) Control N=20.0, M age=69.8 (5.6)	LUISTER: *five training modules with different analytic and synthetic tasks: vowel and consonant identification, themes, voice identification, words, clock reading and competing sentencesAll exercises in silence, speech weighted noise and babble noise*	15-20min/day, 5x/week for 12 weeks*80% completed recommended training time*	Participants progressed past initial starting signal-to-noise ratio by at least 6 dB	Improved speech-in-noise (larger when streamed to hearing aid than in free field for the training group), No improvements in inhibition, task switching or working memory updating	No improvements in hearing related quality of life	
Han et al. (2024)[30]	RCT with a passive control	*Bilateral HA-users (>3m)*Total N=41Intervention: N=20, M age=70.5 (6.9)Control: N=21, M age=69.5 (13.8)	Chat-based mobile auditory training*Word and sentence training using Google cloud text to speech software, user had to resolve questions*	30 min/day for 2 months*19/20 participants completed at least 50% of training, 85% trained more than required*		Procedural effect in both groups: more improvements in word and sentence perception tests, no improvements in phoneme and consonant perception tests	No improvement in hearing handicap inventory or the international outcome inventory for hearing aids	
* *Koprowska et al. (2024)*[35]	RCT with an active control*audiobooks + MPC*	*HA-users (>1y)*Total N=20Training: N=10, M age=71.7 (5.2)Control: N=10, M age=69.4 (5.5)	Modification to the SchooLoo programme *Phoneme in noise training: logatomes of the Danish nonsense word corpus in speech-weighted noise*	1.5h/day, 6 sessions over 6 weeks*Adherence not mentioned*		The training group improved in speech-in-noise at difficult signal to noise ratios, with higher peak pupil dilation. The magnitude of pupillary response increased more in the training group: results suggest higher effort after intervention.		

** Van Wilderode et al. 2025*[48]	RCT with active and passive control	*Persons with SiN problems*Total: N=60Training: N=20, M age= 70.4 (7.2)Active control: N=20, M age= 68.4 (7.8)Passive control: N=20, M age= 69.4 (7.8)	Competing talker paradigm with Dutch/Flemish speakers (five listening scenarios)	15 min/day, five times per week during four weeks*62% completed 300 min, 16% completed 250-300 min*	All three groups improved significantly on training materials following training.	Speech-in-noise improvement following trainingNo improvements in phoneme perception in noise, temporal modulation transfer function, inhibition, dual-task listening posture	No benefit on SSQ, Effort assessment scale, Communication Assessment Scale	SiN benefits retained after 4 weeks, not after 8 weeks, possibly due to lack of power
** van Wieringen et al. 2025*[42]	RCT with a passive control	*Experienced HA and CI users (>6m)*Total: N=130Training: N=56 HA + 1 CI + 8 CI&HAControl : N=55 HA + 1 CI + 9 CI&HA	ALICE: *monitoring module with digits-in-noise and phoneme identification tasks, training module with different listening exercises (e.g. vowel and consonant identification, themes, suprasegmental (voice recognition and prosody), sentences (clock reading, realistic sentences)), and a counselling module.All exercises in silence, speech weighted noise and babble noise.*	15 min/day, five times per week during eight weeks*71% completed 600 min (or more), 22% completed 300-600 min*	Training group improved significantly on training materials following training.	Improvements in speech-in-noise for the training group.	No improvement on SSQ, Effort Assessment Scale, Communication Assessment Scale, International Outcome Inventory for Hearing Aids	

RCT= randomized control trial, HA = hearing aid, CI= cochlear implant, SiN= speech-in-noise, SSQ= speech, spatial and qualities questionnaires. GHAPB= Glasgow Hearing Aid Benefit Profile

The fourteen studies which reported an improvement in (untrained) speech-in-noise perception following training are indicated by an asterisk.

On-task improvements

Thirteen out of 28 studies did not report improvements in the training materials (on-task improvement), sometimes because the program did not allow this (e.g., Olson et al. (2013) [37], DVD exercises). The other 15 studies all reported an improvement in the trained materials; 5 studies in HA users [32,42,43,49,51], 4 in CI users [36,38,42,53], and 6 in the group without sensory management [9,29,31,34,46,48]. Some studies reported decreased signal-to-noise (SNR) levels at the end of training on trained materials [32,34,36,38,42,43,48,50], or improved scores on a certain SNR level [9,32]. More details are provided in Table 3 (detailed overview of studies) and Table 4 (synthesis of studies).

Two studies including adults with a HI (without sensory management) assessed on-task learning in time-compressed speech and rapid speech and showed improvements in these measures [34,51], and two studies in adults with HI showed improvements in trained cognitive tasks [9,51]. The LACE training showed improved speech in noise perception, compression on rapid speech, word memory, and more use of linguistic context in two studies [9,46,51]. In another LACE study by Olson et al. (2013) [37], training improvements were not reported.

Transfer of learning toward untrained tasks: speech in noise perception

The main objective of auditory training is that it leads to transfer to improvements in untrained tasks, such as speech in noise perception (SiN). Twenty-six out of 28 studies assessed SiN (words, sentences). Of these 26 studies, 14 studies reported that the intervention group improved following training; 5/9 studies with HA users [35,37,42,43,47], 7/11 studies of the group without sensory management [9,41,44-46,48,50], and 3/6 studies with CI participants [39,42,53]. These are indicated with an asterisk in Table 3 and with 'yes' in Table 4.

Several studies showed the functional benefit of one outcome measure: Whitton et al. (2017) [50] reported improvements in sentences in noise, but performance in words in noise did not improve following training. Although both SiN outcome measures in the study of Sweetow and Sabes (2006) [9] assessed sentences in noise perception, only the QuickSIN showed improvements, while the HINT sentences did not. Two studies reported improved vowel and consonant perception [44] or word recognition [38]. The other twelve studies reported no improvements. Two (of the 28) studies did not include any measures of SiN

performance [44,52]. Five studies reported improved SiN in both the intervention and the control conditions [27,30,34,36,37].

Transfer of learning toward other untrained tasks

Four out of eight studies with HA users determined a transfer to untrained tasks other than SiN. Following CV and VC training, HA users showed improved phoneme recognition in untrained voices [49]. Using the LACE paradigm, Olson et al. (2013) [37] the training group showed improved competing talker intelligibility. ReadMyQuips showed improvements in ERP measures [47]. Koprowska et al. (2024) [35] reported that the magnitude of pupillary response was larger for the training group following phoneme in noise training. None of the studies with CI users reported a transfer to other untrained measures. Four out of nine studies with HI participants without sensory management demonstrated some transfer to other untrained measures [9,29,44,45]. Anderson and colleagues (2013) [45] reported improvements in central auditory processing. Sweetow and Sabes (2006) [9] showed improved listening span and inhibition, and Ferguson et al. (2014) [29] reported improved working memory and divided attention following training. Yu et al. (2017) [44] reported transfer to untrained consonants but not to untrained vowel perception.

Self-perceived benefits

Thirteen out of 28 studies assessed self-reported benefits (6 studies with HA users, 4 studies with listeners without sensory management, and 3 studies with CI users), see Tables 3 and 4. Five of these 13 studies reported an improvement in self-report for the intervention group, not the control group [37,38]. One of these was a study with HA users [9,29,37,38,41].

Three of the seven studies with CI users measured self-reported benefits [33,36,38], of which only one study reported an improvement in the intervention group [38]. Magits et al. [36] reported an improvement for both the intervention and the control groups. Ihler et al. [33] reported an effect on the hearing aid profile but did not perform any statistics to confirm conclusions.

Only four out of 11 studies with HI persons without sensory management examined self-reported benefits following training [9,29,41,48]. In three studies, the intervention group reported significantly better self-perceived benefits after training. Sweetow and Sabes [9] reported improvement in the self-reported hearing handicap and an improvement in the communication scale for older adults. Ferguson et al. [29] reported an improvement in the overall disability index, not with the Speech, spatial, and quality questionnaire. Saunders et al. [41] indicated a larger improvement for the group that received the FM-system, counselling, and auditory training. Saunders and colleagues [41] also reported an improvement in the same group's cognitive self-report scale. They did not find any self-reported improvements in the psychosocial impacts on the intervention scale. Van Wilderode et al. [48] reported no self-perceived benefit for only the intervention group.

Duration and adherence

Recommended training time varied across the 28 studies. Most programs involved daily or near-daily sessions lasting between 15 and 90 minutes, spanning 2 to 16 weeks.

Adherence was reported for 20/28 studies. Fourteen studies reported good adherence (> 80% of participants completed recommended training time) [29,30,32-34,36,37,39,40,43,46,47,51,53], five studies reported average adherence (50-80% of participants completed recommended training time) [27,38,42,48,52], and one study indicated poor adherence (< 50% of participants completed recommended training time) [41]. No differences were observed between HA users, persons without sensory management and CI users.

Table 4: Synthesis of the included studies.

Study	Participants	Type of training	Stimuli	Counseling	On-task	Generalization	Self-perceived benefit	Retention	Quality Score
Stecker et al. (2006) [49]	HA	Auditory-Perceptual	Syllables	No	Yes	/	/	Yes	Moderate
Sweetow Sabes (2006) [9]	NSM	Auditory	Mixed	Yes	Yes	Yes	Yes	/	Low
Anderson et al. (2013) [45]	NSM	Auditory-Cognitive	Mixed	No	/	Yes	/	/	Low
Olson et al. (2013) [37]	HA	Auditory	Mixed	Yes	/	Yes	Yes	/	Moderate
Humes et al. (2014) [31]	NSM	Auditory	Words and phrases	No	Yes	No	/	/	High
Ferguson et al. (2014) [29]	NSM	Auditory	Phonemes	No	Yes	No	Yes	Yes	Low
Karawani et al. (2016) [34]	NSM	Audio-visual training	Passages	No	Yes	No	/	/	Moderate
Abrams et al. (2015) [27]	NSM	Auditory	Mixed	No	/	No	/	/	Low
Schumann et al. (2015) [53]	CI	Auditory	Syllables	No	Yes	Yes	/	Yes	Moderate
Rishiq et al. (2016) [40]	HA	Auditory	Mixed	No	/	No	/	/	Low
Saunders et al. (2016) [51]	HA	Auditory	Mixed	Yes	Yes	No	No	No	Moderate
Ihler et al. (2017) [33]	CI	Auditory	Mixed	No	/	No	No	/	Moderate
Rao et al. (2017) [47]	HA	Auditory-Cognitive	Mixed	No	/	Yes	/	/	Low
Whitton et al. (2017) [50]	NSM	Audio-motor	Mixed	No	Yes	Yes	/	/	Moderate
Yu et al. (2017) [44]	NSM	Auditory	Consonants	No	/	Yes	/	Yes	Low

Saunders et al. (2018) [41]	NSM	Auditory	Mixed	No	/	Yes	Yes	/	Moderate
Humes et al. (2019) [32]	HA	Auditory	Words and sentences	No	Yes	No	No	Yes	High
Jiam et al. (2019) [52]	CI	Auditory	Music	No	/	/	/	/	Moderate
Chari et al. (2020) [28]	CI	Auditory	Melodic contour	No	/	No	/	/	Low
Reis et al. (2021) [38]	CI	Auditory	Mixed	No	Yes	No	Yes	Partial	Moderate
Reynard et al. (2022) [39]	CI	Auditory	Sounds, syllables, words	No	/	Yes	/	No	Moderate
Magits et al. (2023) [36]	CI	Auditory	Mixed	No	Yes	No	No	Yes	High
Lai et al. (2022) [46]	NSM	Auditory-Cognitive	Mixed	No	Yes	Yes	/	/	Low
Van Wilderode et al. (2023) [43]	HA	Auditory	Mixed	No	Yes	Yes	No	/	Moderate
Han et al. (2024) [30]	HA	Auditory	Word and sentences	No	/	No	No	/	Low
Koprowska et al. (2024) [35]	HA	Auditory	phonemes	No	/	Yes	/	/	Low
Van Wilderode et al. (2025) [48]	NSM/HA	Competing talker	Sentences	No	Yes	Yes	No	Partial	High
van Wieringen et al. (2025) [42]	HA/CI	Auditory	Mixed	Yes	Yes	Yes	No	/	Moderate

HA=hearing aid, NSM=no sensory management, CI=cochlear implant

'Yes' indicates presence of counselling, improvement of training, generalization, self-perceived benefit by training group, retention. 'No' indicates absence of counseling, of an effect, of generalization, of self-perceived benefit and retention. '/' indicates that outcome, generalization, self-perceived benefit, retention, was not measured.

Retention

Only three out of ten studies assessed retention of performance in HA users (Table 4). The survey of Stecker et al. (2006) [49]

showed that the improvements in the trained tasks remained after 8 weeks; the study of Humes et al. (2019) [32] showed that improvements in the trained materials remained for 8.5 months. However, the Saunders et al. (2016) [51] study showed no retention after 6 months.

Four out of seven studies with CI users assessed whether benefits remained after training stopped. The survey by Schumann et al. (2015) [53] indicated that SiN improvements remained for at least 6 months. Similarly, Magits et al. (2023) [36] found that both SiN improvements and self-reported benefits on HRQoL remained after 8 months in both the intervention and the active control groups. However, Reynard et al. (2022) [39] reported that improvements in SiN remained but decreased over time. Similarly, Reis et al. (2021) [38] indicated a decline in word recognition improvements, while the improvement in self-reported quality of life remained.

Only three out of eleven studies measured retention of performance in persons without sensory management. Ferguson et al. (2014) [29] showed that improvements retained for at least one month, while Yu et al. (2017) [44] indicated that improvements remained after 2 weeks. Van Wilderode et al. (2025) [48] reported that improvements remained after 4 weeks, but not after 8 weeks.

Discussion

In this study, we reviewed whether evidence exists to enhance daily-life listening and the ability to manage difficult listening situations through tailored, self-guided auditory training in adults with (self-reported) hearing impairment. To maintain consistency in the quality grading process, where the presence of a comparator control is a scoring criterion, studies without a control group, such as those using a within-subject repeated measures design (n=7, Figure 1), were excluded to prevent systematic bias against certain study designs. However, it should be noted that RCTs are difficult to conduct in this context, especially for CI users, who generally show highly variable outcomes in listening performance. This hampers establishing baseline performance--matched intervention and control groups with a sufficient sample size to investigate the training benefit. Therefore, a within--subject approach is often the only option in this case. Several of these studies also show the benefits of auditory training with a limited sample size.

Number of studies

Over the past years, the number of studies dealing with self-guided training programs has increased significantly. Six of the 21 studies targeting users with HAs or without sensory management [9,27,29,45,49,50] had been described before in the systematic reviews of Henshaw & Ferguson (2013) [13] and Gaeta et al. (2021) [16]. Of the seven studies with CI users, only the studies of Schumann et al. (2015) [53], Jiam et al. (2019) [54] and Magits et al. (2023) [36] were reviewed previously by Cambridge and colleagues (2022) [17] and Tamati and colleagues (2025) [20]. The increased number is presumably due to increased telehealth and technological possibilities allowing for fully self-guided use of a program in the home setting.

Only 4/28 studies included self-guided (informational) counselling alongside the auditory training. Three used the LACE program [9,37,51], while the fourth examined the ALICE app [42]. Although the integration of counselling in a self-guided training tool builds upon the recommended holistic approach of aural rehabilitation [3], the contribution of counselling to training gains is difficult to evaluate and requires further research.

Efficacy of self-guided training programs

The efficacy of a training program is measured by the extent to which learning transfers to functional benefits in real-world listening (i.e. off-task training outcomes). These functional benefits can be improvements in SiN, cognition (working memory

and attention), and self-perceived benefits. Our systematic review shows that 14/26 studies reported a functional benefit of speech understanding in noise for the intervention group after training. This is relatively low, given the importance of learning transfer as an indicator of training efficacy. Moreover, only three out of these 14 studies also reported improved self-perceived benefits following training [9,37,41]. In general, there is limited transfer to other untrained tasks: eight (out of 17) studies reported improvements in other measures, such as phoneme perception or cognitive outcomes.

Several factors may contribute to the conflicting evidence on transfer to untrained measures, one being the sensitivity of the outcome measures used to evaluate performance. Capturing daily life listening difficulties in adults requires methods that reflect real-world challenges and the individual's perceptions of their listening abilities. Various measures were used in the included studies to assess functional benefit: these were bundled under 'SiN' and 'self-report'. Both SiN and self-report have value, and each has strengths and limitations. SiN testing is done to assess speech perception in noisy environments, which is a common complaint in daily life. However, measures are conducted in controlled environments, which may not fully replicate real-life listening conditions. In an attempt to address more real-life listening difficulties, Van Wilderode and colleagues (2025) [48] used a dual-task (listening-posture) paradigm to evaluate the efficacy of the training paradigm. However, this paradigm was not particularly sensitive to capturing potential changes following training. In addition, these outcomes often do not capture the cognitive or emotional burden of listening difficulties. Questionnaires might be more suitable to assess self-reported listening difficulties in daily life. They provide insight into how listening difficulties affect the quality of life, confidence, and social engagement, but they can also be influenced by personality, situational factors and expectations [54]. On the one hand, participants often lack insight into beneficial changes that do occur. On the other hand, many of the self-report measures are not sensitive to changes in performance. A solution could be to use Ecological Momentary Assessment (EMA), where data are collected repeatedly in real-time through a smartphone. EMA can offer a context-specific alternative to static questionnaires [55], and can be integrated into telehealth programs to support more interactive and personalized counselling. Another possibility is to conduct the evaluation of functional benefits using virtual reality to mimic real-world listening scenarios for a more nuanced assessment (e.g., Devesse et al. (2020) [56]). Irrespective of efficacy, any process that may help increase confidence, enhance skills, or improve attention is important. Auditory training may have less impact on improving speech understanding in noise but may reduce the perceptual effort required to understand spoken language. Only the study of Koprowska et al. (2024) [35] aimed to measure listening effort through pupillometry. Reductions in perceptual effort have been captured with objective measures (e.g., Koprowska et al. (2024) [35]) or with behavioral measures (e.g., Sommers et al. (2015) [57]). If listeners experience less effort they may be more likely to engage in social activities even if their speech understanding in noise does not improve.

The 14 studies reporting a transfer of learning to SiN employed a variety of bottom-up and top-down training exercises in the following self-guided programs: LACE (3x), Brain Fitness cognitive training, nonsense syllables, ReadMyQuips, Sensorimotor video games, LUISTER, ALICE, and a serious game scenario. Bottom-up exercises focus on sound discrimination and identification, while top-down exercises focus on developing higher-order skills using realistic materials such as sentences. On-task improvements were observed in all studies that could assess improvement on trained materials, confirming that training improves sensory processing.

It is known that repeated exposure to auditory stimuli can strengthen neural connections in auditory pathways, improving sound discrimination, speech perception, and cognitive functions like attention and memory (e.g., Anderson & Kraus (2013) [58], Ying et al. (2025) [59]). Possibly, this repeated training leads to more specific performance [60], thereby hampering generalization to untrained conditions. More research is needed to identify core mental processes that operate in multiple task domains and hence develop materials that require adaptive, high-level cognitive functions (e.g., communication strategies).

Our analysis of the different studies shows that self-guided training does allow for good adherence. However, variability in adherence and dropouts remains a concern, and more research is needed to understand the factors underlying motivation and en-

gagement. Henshaw and colleagues (2015) [61] used self-determination theory [62] to determine what factors influence the individual's motivation and maximize intrinsic and extrinsic motivations for adherence. Engagement and adherence to computer-based auditory training are influenced by intrinsic motivation (e.g., hearing difficulties) and extrinsic motivation (e.g., the desire to help others with hearing loss). Self-management of hearing loss requires motivation and dedication, and, as a result, persons become aware of their hearing difficulties

Additionally, the lack of long-term follow-up data limits understanding of the lasting effects of these interventions. More insights into these aspects would allow us to understand the mechanisms underlying training and whether training should be administered briefly or should be retained for a longer period albeit at a lower intensity.

Quality

Although all included studies had a comparator control, the methodological quality of the studies was generally low to moderate. Of the 14/26 studies that reported transfer to untrained SiN, 6 were of low quality, and 7 were of moderate quality (and one high quality). Only five of these 14 studies included a power calculation [41-43,47,48]. Following the recommendations of Henshaw and Ferguson (2013) [13], some improvements in methodological quality were observed. However, key limitations persisted, most notably a lack of participant blinding, absence of power calculations, absence of training feedback, absence of self-reported questionnaires, lack of compliance reporting, and absence of follow-up assessments to evaluate long-term training effects. About half of the studies had sample sizes below 30 participants or featured unbalanced groups. This highlights the need for additional high-quality RCTs to further substantiate the evidence base of self-guided auditory training programs. Although high-quality research grounded in strong theoretical frameworks remains essential [63], recruiting sufficient participants for such studies can be challenging.

Nevertheless, engaging in auditory training may still offer meaningful benefits in practice. While there are still significant challenges, such as more realistic training programs and outcomes, we believe that self-guided training programs provide greater accessibility and flexibility, allowing users to engage in training and counselling at their own pace and in their preferred environment, which can lead to increased understanding and self-empowerment. The standardized delivery of training content ensures consistency across sessions and users, while built-in data logging supports progress tracking and adherence monitoring—features that are difficult to implement consistently in clinician-based settings. These programs also reduce the demand for clinical resources, enabling professionals to focus on more complex aspects of care, such as counselling and device management.

Subpopulation differences

This review intentionally included studies involving both HA and CI users, as well as persons without sensory management ("no sensory management", NSM). Overall, findings were largely consistent across these subpopulations. Regarding study quality, all three categories (i.e. low, moderate, high) were represented within each group, but NSM studies were somewhat more frequently rated as low quality (6/11), compared to HA (4/10) and CI studies (1/7). The stimuli used during training were comparable across subpopulations, except for music-based stimuli, which were solely used in CI studies. On-task effects were measured in about half of the studies in each group (5/10 HA, 4/7 CI, 6/11 NSM), which all demonstrated significant improvements in the intervention group. Untrained speech-in-noise perception was assessed in nearly all studies (9/10 HA, 6/7 CI, 11/11 NSM), with approximately half showing significant improvements – similar across HA, CI, and NSM studies. However, the inclusion of other untrained tasks (e.g. cognitive measures) varied considerably: none of the CI studies included such tasks, whereas most HA (8/10) and NSM (9/11) studies did. Among these, about half reported significant improvements, regardless of subpopulation. Self-perceived benefits were assessed more frequently in HA studies (6/10) than in CI (3/7) or NSM (4/11) studies; however, significant improvements were reported mainly in NSM studies (3/4), compared to only 1/6 HA and 1/3 CI

studies. Finally, retention of training effects was evaluated slightly more in CI studies (4/7) than in HA (3/10) or NSM (3/11) studies, with CI users also showing the most consistent retention (4/4 vs. 2/3 in both HA and NSM).

Despite different auditory profiles and different levels of experience with sensory management, the objectives of auditory training are similar across these subpopulations: to (re)learn to make sense of sound, improve attentional skills and auditory memory, and ultimately improve speech understanding in adverse listening conditions. Moreover, many individuals with a HI use both a CI and a HA. Therefore, evaluating the efficacy of auditory training across these groups requires an inclusive perspective that focuses on common outcomes rather than technological distinctions.

Conclusion

Over the past years, self-guided auditory training programs have surged due to technological advancements. Most studies reported good adherence, as evidenced by data logging, which is one of the key advantages of telehealth approaches. Counselling is currently limited in self-guided programs, but recent innovations demonstrate the potential to deliver information, guidance, and support to persons with listening difficulties. While the transfer to untrained tasks remains limited, all studies report improvements in the trained tasks, confirming that practice improves skills and abilities in persons with different auditory profiles. Self-guided auditory training programs are valuable in hearing rehabilitation, enabling users to practice listening skills at their own pace and in their preferred environment. Although the methodological quality of studies has improved relative to earlier reviews, the demand for rigorously designed, high-quality RCTs remains substantial.

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Author Contributions

A.v.W. , LL, and M.V.W. contributed to the study conception and design. They reviewed and analyzed data and wrote the manuscript.

Declaration of Conflicting Interests

The authors declare no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

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