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Benefits of Auditory Training for Aided Listening by Older Adults

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Abstract

Purpose—In this article, the authors provide an overview of auditory training programs for aided listening by older adults, review criteria for evaluating effectiveness, summarize results of published studies, report on 2 training programs currently undergoing assessment, and discuss directions and needs for future research.

Method—Experiments are ongoing to evaluate 2 individual, computer-based speech-perception training programs: Indiana University (IU) word-based training and the Speech Perception Assessment and Training System (SPATS). Training and control subjects are older adults with mild-to-severe hearing loss. Subjects train for about 30 hr with monaurally presented, spectrally shaped stimuli (IU) or through loudspeakers with their own hearing aids (SPATS). Displays and feedback use auditory and visual/orthographic cues. Outcome measures include objective measures of speech recognition in noise and other training benefits.

Results—Significant improvements were observed in open-set recognition of trained sounds, words, phrases, and sentences. Large individual differences in training benefit were apparent. Generalization varied with the speech-perception task, competing noise, listening strategy, and pretraining scores.

Conclusions—High-level evidence is needed to support the effectiveness of auditory training for older adults as a supplement to aided listening. Studies are needed to predict who will benefit from specific types of training, to assess compliance and engagement, and to discover benefits beyond communication.

Keywords

speech-perception training; aging; hearing aids; IU word-based training; SPATS

Speech recognition difficulty is a common complaint of older adults with hearing loss, especially for listening in complex or noisy environments. Whereas most hearing aids increase speech audibility in relatively quiet environments, they may have limited benefit for speech recognition in noisy environments if they are not able to improve the signal-to-noise ratio (SNR). In some situations, other hearing-assistive technologies may be used to improve the SNR, such as personal frequency modulation (FM) systems, noise reduction circuits, or

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directional microphones. However, when even these technologies provide a less-than-optimal SNR, a complementary approach to benefit speech recognition is to train the listener to make better use of available, aided speech information. This may be accomplished through speech reading, cognitive training, and/or auditory training, the latter of which is the focus here. That is, as a supplement to aided listening, an effective auditory training program may improve the use of audible speech information, enhance communication abilities, increase the effectiveness of hearing aids, and improve quality of life.

In contrast to early auditory training programs designed for children with severe hearing loss, many newer training programs target older adults who use hearing aids. One advantage of programs that are designed for older adults is that these adults have more moderate hearing loss. However, unknown higher level deficits or age-related cognitive declines, such as those related to working memory, attention, or executive function, may limit the effectiveness of interventions that focus solely on improving audibility or SNR.

Although promising results for individual and group auditory training programs for adults were reported in the 1970s and 1980s (e.g., Walden, Erdman, Montgomery, Schwartz, & Prosek, 1981; Montgomery, Walden, Schwartz, & Prosek, 1984), interest in and evidence supporting auditory training has been limited, perhaps due to technical restrictions of those programs and the need for laboratory-based training extending over many days and weeks. More recent training programs—developed to utilize newer technology and automated, home-based training—have generated renewed awareness and additional evidence of benefits of auditory training for older adults who use hearing aids (e.g., Boothroyd, 2010; Kricos & Holmes, 1996; Levitt, Oden, Simon, Noack, & Lotze, 2011; Pichora-Fuller & Levitt, 2012). For training and testing, these newer programs (a) focus on individual sounds or clusters, commonly used words in isolation, or words in phrases or sentences with context, referred to as an “analytic” approach (e.g., Stecker et al., 2006); (b) emphasize the role of contextual and redundant information, cognitive skills, communication strategies, and comprehension, referred to as a “synthetic” approach (e.g., Sweetow & Sabes, 2006); (c) include multiple talkers and speech-like, fluctuating background sounds to simulate realistic listening environments; and (d) assure audibility using spectrally shaped speech or participants’ own hearing aids. The use of computers and touchscreen monitors for training and testing supports several innovative features, including (a) automated presentation and scoring, (b) closed-set identification tasks, (c) choice of displays and feedback including combinations of auditory, video, and visual/orthographic cues, (d) customized training paradigms with curricula that can be adjusted based on individual performance, (e) extended durations of training, and (f) an ability to transition to home-based training.

Evaluating the Effectiveness of Auditory Training

The effectiveness of auditory training programs can be evaluated according to several key criteria. At a minimum, it is expected that significant improvements will be observed for tasks (e.g., closed-set recognition) and stimuli (e.g., monosyllabic words in isolation spoken by a single talker) that are used during training. Effectiveness of a program may also relate to the minimum amount of training necessary for maximum benefit and the shape of the function relating performance improvement to hours or sessions of training (e.g., a “doseresponse” for training). Given that some tasks and stimuli may not be representative of real-world communication, it is important to assess the extent to which training with one set of tasks or stimuli results in improvements for novel (untrained) speech stimuli, novel talkers, and novel competing noises or messages. Benefits of training for either trained or untrained tasks should extend after the formal training period has ended; such retention may require periodic “refresher” sessions. It is also possible that training to improve perception of specific component parts of speech may generalize to improvements for more basic auditory detection or discrimination tasks (or vice versa; Tremblay, Shahin, Picton, & Ross, 2009). Other advantages of auditory training may relate to declines in self-reported hearing handicap or communication difficulties. Benefits for non-auditory measures beyond communication may be evident, such as reductions in mental demand or effort related to listening, changes in attention, or improvements in multisensory integration. Finally, auditory training programs can be assessed with respect to participants’ compliance with the scheduled tasks and with individualized computer-based learning, and engagement with the goals of the training program (Tye-Murray et al., 2012).

It is clear that strong evidence of each of these potential auditory training benefits for older adults is needed. In the past few years, two reviews of individual auditory training programs for adults have been published: a systematic review and qualitative analysis of six studies by Sweetow and Palmer (2005) and a meta-analysis of these six studies plus four additional studies meeting the same search criteria by Chisolm and Arnold (2012). While pointing out limitations in study designs (including small sample sizes, heterogeneous outcome measures, inconsistent use of control groups and randomization, and unoptimized training regimens), Sweetow and Palmer reported, with caution, that some evidence supported individualized training for adults with hearing loss; use of a synthetic approach was associated with improved listening strategies. The subsequent meta-analysis and quality assessment by Chisolm and Arnold included only studies with objective measures of speech recognition. Most of the interventions in these studies were judged to be “equivocal” or “suggestive” of benefit with small effect sizes, whereas the meta-analysis of combined studies suggested a small, but reliable benefit for short-term improvements in speech recognition.

Assessment of Two Speech-Perception Training Programs

With a goal of providing high-quality evidence from carefully controlled, large-scale studies on the use of computer-based speech-perception training for older adults as a supplement to aided listening, two experiments are currently being conducted at the Medical University of South Carolina (MUSC) to evaluate two established training programs: Indiana University (IU) word-based training (Humes, Burk, Strauser, & Kinney, 2009) and the Speech Perception Assessment and Training System (SPATS; Miller et al., 2008). Table 1 summarizes the features, experimental methods, and outcome measures of each training program.

Key findings from previous studies using IU word-based training show about a 20% increase in performance for trained words and phrases, which generalized to sentences and novel talkers, increased benefit with auditory + visual feedback, and some retention of benefit 6 months post-training (Burk et al., 2006; Burk & Humes, 2007, 2008; Humes, Amos, & Strausser, 2009). The purpose of the MUSC study was to include new investigators and a laboratory out-side IU to replicate training outcomes for communication, a well-matched control group of older adults, an expanded cognitive battery, and additional physiological (pupillometry) and neurobiological (neuroimaging) outcome measures. Briefly, preliminary results revealed that recognition of trained words increased by about 18 rationalized arcsine units (rau) following training and that benefit generalized to untrained sentences and novel talkers presented with the same noise background. No significant improvements were observed in the untrained control group.

The SPATS project is part of a multisite cohort study, currently including two sites and soon expanding to six sites, to include 225 adults training with their own hearing aids using either SPATS or an alternate form of “listening” training. The goals are to determine the benefit of extended training (about 30 hr) to hearing-aid use and satisfaction; to assess the benefit of syllable component training to sentence recognition; to predict training benefit from pretraining speech recognition, spectral and temporal resolution, general cognitive abilities, and linguistic skills; and to evaluate longer term retention and participant compliance and engagement. Briefly, preliminary results revealed that recognition of trained syllables in quiet and sentences in babble improved by roughly 8 and 12.6 rau, respectively, with most trainees improving significantly for each but exhibiting less improvement for trained syllables in noise. No significant improvements were observed for the untrained control group. With regard to generalization, no significant improvement was observed for untrained sentences, which included novel talkers and babble and used a different (adaptive) listening strategy, or for connected speech, for which pretraining scores were relatively high.

Summary and Conclusions

For both speech-perception training programs, significant improvements were obtained by older adults in open-set recognition of trained sounds, words, phrases, and sentences. There was some generalization to untrained stimuli, although generalization varied with differences in the speech-perception task, type of competing noise, listening strategy, and pretraining performance. Moreover, there were large individual differences in training benefit. Preliminary results did not reveal strong predictors of training benefit related to factors such as magnitude of hearing loss, age, hearing-aid characteristics, or cognitive function. Some results suggest that good pretraining performance may limit benefit, although these findings may simply reflect the consequences of ceiling effects. Additional predictors of training benefit remain to be determined from ongoing analyses.

Assessments of these speech-perception training programs highlight the need for additional high-level evidence to support the effectiveness of auditory training for older adults as a supplement to aided listening in noise. Studies are needed to provide evidence to predict who will benefit from specific types of training; to assess compliance and engagement, especially for home-based training; and to discover benefits beyond communication. Finally, new training tools are needed to increase access for larger numbers of older adults with hearing loss, including home-based systems, tablet platforms, and mobile apps for download.

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Table 1

Description of two speech-perception training studies.

Study characteristic	IU word-based training	SPATS
Study type	Cohort study with control, single site	Cohort study with control, multiple sites
Training subjects	14 older adults (61–85 years) F/M = 6/8	24 older adults (54–86 yr) F/M = 4/20
Control subjects (passive)	15 older adults (60–88 years) F/M = 6/9, matched to training group	12 older adults (59–82 yr) F/M = 4/8, matched to training group
Hearing loss	Mild-to-moderate sloping SNHL	Mild-to-severe sloping SNHL
Hearing-aid users	No	Yes
Intervention	Individual computer-based training	Individual computer-based training
Training stimuli	Frequent words, phrases (closed set)	Syllables, sentences (closed set)
Talkers	4	8–12
Background	Speech-shaped 2-talker ICRA noise	Quiet and multitalker babble
Listening condition	Monaural with headphone	Sound field using own hearing aid(s)
Training duration	~33 hr	~30 hr
Subject interface	Auditory/orthographic display and feedback	Auditory/orthographic display and feedback
Audibility control	Spectral shaping to replicate well-fit hearing aid	Amplification with own hearing aid(s)
Pre/posttesting	Trained words and phrases, untrained VAST and CID sentences	Untrained words and sentences (WIN, QuickSin, CST-A, CST-AV)
Other training outcomes	Pupillometry, structural and functional neuroimaging	Pupillometry, self-assessed task load, hearing-aid satisfaction
Other measures	Cognitive function	Cognitive function, nonspeech temporal/spectral resolution

Note. IU = Indiana University, SPATS = Speech Perception Assessment and Training System, SNHL = sensorineural hearing loss, ICRA = International Collegium for Rehabilitative Audiology, VAST = Veterans Affairs Sentence Test (Bell & Wilson, 2001), CID = Central Institute for the Deaf Everyday Sentence Test (Davis & Silverman, 1978), WIN = Words in Noise Test (Wilson, 2003), QuickSin = Quick Speech in Noise Test (Killion, Niquette, Gudmundsen, Revit, & Banerjee, 2004), CST-A = Connected Speech Test (audio; Cox, Alexander, & Gilmore, 1987), CST-AV = Connected Speech Test (audiovisual; Cox, Alexander, Gilmore, & Pusakulich, 1989).