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Critical Review:
The Benefits of Auditory Training for Adults with Mild to Moderate Sensorineural Hearing Loss.

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The purpose of this critical review is to address the question: Based on behavioral outcome measures, should audiologists provide Auditory Training for adults with mild to moderate sensorineural hearing loss? A review of the current literature revealed six studies for critical analysis. Study designs included one non-randomized control study, one non-randomized cohort study, one prospective randomized control study, one double blind randomized control study, one randomized control study, and one critical review. Four of the six studies used computer-based auditory training programs as their protocol. Behavioural outcome measures were used to evaluate the efficacy of Auditory Training (AT). Although the evidence provided by these studies suggest that Auditory Training can improve behavioural outcomes, the effects were modest and there was a lack of large sample sizes. Future investigation is warranted into the benefits of auditory training above amplification, long-term benefits of auditory training, specified auditory training protocols, and real world benefit.

Introduction

The World Health Organization (2010) reports that the number of individuals with hearing loss is rising every day due to the growing elderly population and increased life span. CASLPA (2005) indicates that hearing loss is the third post prevalent chronic disability in the elderly. The population with hearing loss is projected to make up ¼ of the population by the year 2041 (Statistics Canada, 2006). As the elderly population is the fastest growing age group, the prevalence of hearing loss is expected to grow as well, and the need for amplification and aural rehabilitation will also increase.

Although the main form of rehabilitation for adults with hearing impairment is amplification, many adults choose not to wear hearing aids or continue to wear them while continuously experiencing hearing difficulties (Brouns, Rafai, and Price 2010). The typical presbycusic hearing loss causes adults to experience difficulties perceiving speech. These difficulties increase with the presence of background noise (Burk & Humes, 2008). Hearing aids may increase the signal to noise ratio, but in many cases, this is not enough to improve speech perception in noise (Kricos, 2006).

Another approach that may decrease problems listening in noise is to "train the listener to make better use of the existing SNR" (Burk & Humes, 2008). Auditory Training (AT) is a part of aural rehabilitation in which a prescribed protocol of various listening exercises is used to improve an individual's ability to perceive speech (Brouns et al., 2010). Historically, studies have shown improvements in speech perception with auditory training, however due to technical limitations and length of the training programs, the cost-benefit ratio for patients to partake in such programs was not favorable. The recent advent of training programs that could be completed on a PC at home has given rise to a renewed interest in AT. If clinicians are to suggest these programs, it should be found in the literature that auditory training programs are beneficial for the client. The results of this critical review will give clinicians the information to make informed decisions about implementation of AT.

Objectives

The primary objective of this paper is to critically evaluate the current body of research addressing the benefits of auditory training in adults with mild to moderate sensorineural hearing loss in order to rationalize its use in the clinical setting.

Methods

Search Strategy

Computerized databases, including CINAHL, PubMed, Medline, OVID SP and Google Scholar were searched, using the following search strategy:

(auditory training) OR (perceptual training) OR (listening training)AND (adult$) AND (hearing loss) OR (hearing impairment)

The search was limited to articles written in English from 1970 to 2011 with adult humans.

Selection Criteria

The studies selected for inclusion in this critical review paper were required to investigate the effects of auditory training on adults with mild to moderate sensorineural hearing loss. The studies included used a range of various auditory training protocols. A criterion was set to include studies that used behavioural outcome measures.

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Data Collection

A review of the literature yielded one nonrandomized control study (level 2b), one nonrandomized cohort study (level 2b), one prospective randomized control study (level 1), one double blind randomized control study (level 1), one randomized control study (level 1) and one critical review (level 2b+). Four of the six studies used PC-based auditory training programs. The overall level of evidence in this critical review is compelling.

Results/Discussion

Non Randomized Control Trial

Burk and Humes (2008), conducted a non-randomized control trial and examined the impact of repeated presentations of words in noise on understanding of trained and untrained words in noise on eight older listeners with mild to moderately severe hearing loss. The goals of the proposed training protocol were to increase generalization of words and sentences and examine retention of materials.

Participants in this study completed a 12-week PC-based analytic AT program that consisted of both word and sentence stimuli that were lexically easy or lexically hard. Burk and Humes (2008) described lexically hard words, as occurring less frequently in conversation and as differing by one phoneme from other words. Lexically easy words are those that are used frequently in conversation and have few phonemic neighbours. Open and closed word recognition tests were used to evaluate the efficacy of the training program after 12 weeks. Participants attended 3 sessions per week, completing a total of 20-24 sessions. Upon completion of the training protocol, participants were asked to return weekly for up to 14 weeks to monitor retention of the training materials. Listeners were measured at baseline, and at a midway point after hard word training sessions (9-11 weeks), and then again at the end of the easy word training protocol (20-24weeks).

All participants improved their open set word recognition score (WRS) on both the hard and easy words post-training (95% C.I.). In addition 6/8 participants improved upon their baseline closed set performance for both easy and hard words. When participants were trained on hard words they showed a significant improvement in performance from baseline with an increase of 47.4%, $t(7) = -8.65$ ($p < .001$)in an open-set response test and 16.4%, $t(7) = -10.18$ ($p < .001$) in a closed-set response test. When training was switched at the midway point to easy word training, listeners performance improved more than in the initial hard word training. The open set WRS for easy words improved from 48.8% at baseline to 89.2% following easy word training, $t(7) = -12.73$ ($p < .001$). The closed set WRS for easy words showed an improvement of 17.2% from baseline, $t(7) = -5.43$ ($p < .001$). The increase in performance measured in this study could generalize to word recognition spoken by a novel talker but not to untrained words or sentences.

Burk and Humes (2008) also measured retention of improved word recognition scores for 14 weeks after the training program. They found a slight decline (4.4% after seven weeks) but no significant change in performance. In addition, Burk and Humes (2008) found that after a brief "refresher" auditory training course, participants were able to return to peak performance levels at a faster rate.

Although the implications of this study support the use of AT to improve word recognition performance, the results must be considered with caution. A weakness of this study is the lack of a control group. One cannot infer improvements in word recognition score with auditory training without the use of a control group. In addition, ceiling effects were problematic in this study and the authors dealt with this by using rationalized arcsine units (RAU's). "A problem with such transformations is that the arcsines do not bear any obvious relationship to the original proportions. For this reason, results expressed in arcsine units are difficult to interpret" (Studebaker, G., 1985).

Randomized Control Trial

Stecker, Bowman, Yund, Herron, Roup, & Woods (2006), conducted a randomized control trial to investigate the ability of adaptive perceptual training to improve syllable discrimination in new and experienced hearing aid users. The study consisted of two experimental groups, new (n=23) and experienced (n=8) hearing aid users. Participants in both groups were randomly assigned to either immediate training (IT) or delayed training (DT) groups. The participants in the delayed training groups acted as controls. Stecker et al. (2006) used a PC based protocol to train participants in syllable discrimination for 1 hour/day, 5 days a week, for 8 weeks. Improvements in speech discrimination were evaluated using the nonsense syllable test (NST) in noise.

The new hearing aid user IT group improved their syllable discrimination performance by 10.6% from baseline and the DT group improved their performance by 8.8% from baseline. Both of these improvements were significantly greater than the improvements measured from hearing aid fitting alone, IT group: $F_{1, 21} = 40.5$, $p < 0.001$; DT group: $F_{1, 18} = 33.4$, $p < 0.001$). In addition, the DT group showed improved syllable discrimination once the training protocol was initiated, indicating that it is not crucial to begin a training program immediately after hearing aid fitting to see improvements in syllable discrimination. Performance gains generalized to novel speakers and

retention was maintained for 8 weeks post training. In addition, after training, participants showed greater accuracy for syllable discrimination of difficult phonemes.

The major strength of this study is that it is a randomized control trial and any significant changes from baseline, can be fairly confidently attributed to treatment effect. In addition, the randomization of participants reduces any biases and allows experimenters to be more confident that changes in baseline performance are likely due to the effects of intervention, not confounding variables. The Stecker et al. (2006) study used ANOVA to determine statistical significance of performance changes and to evaluate effect of interaction on results. This increases the confidence that their results are truly a result of the intervention and not just confounding variables.
One weakness of this study is that there was no blinding of the experimenters. Since they were the ones evaluating the participants post training, the lack of blinding could have made them bias towards the treatment groups.

Non-Randomized Control Trial

Bode and Oyer (1970) conducted a non-randomized control trial that used speech discrimination pre and post training to measure the effectiveness of a 1-day auditory training session consisting of 5 x 25-minute training sessions. The participants consisted of thirty-two adults with mild sensorineural hearing loss. The speech recognition tests that were used to evaluate treatment were the Central Institute for the Deaf (CID) W-22, which is a word list consisting of 200 phonetically balanced words, the Rhyme which is a measure of speech sound discrimination ability, and a Semi-diagnostic test. Bode and Oyer (1970) used t-tests to compare the results for before and after training. Results indicate a significant improvement in speech recognition performance of 7.7% on the W-22 ($p<0.01$) and 3.5% on the Rhyme ($p<0.05$). No improvement was measured on the semi-diagnostic test.

A weakness of this study was the lack of a control group. In addition, the auditory training program used in this study was only 1 day long. Since most auditory training programs are performed over several weeks, this limits the ability to apply the results to clinical practice. Finally, this study did not attempt to examine retention of auditory training.

One of the strengths of this study is that it contained a large sample size, which increased the statistical significance of the results. In addition, Bode and Oyer (1970) used t-tests and ANOVA to calculate the significance of results, which allowed them to eliminate extraneous factors and increase the confidence that improvements occurred because of AT.

The results of this study must be approached with caution as the clinical relevance of the training program is questionable given that the intervention was only a one-day training program and there was no investigation regarding long-term outcomes and retention.

Double Blind Randomized Control Trial

Gil and Ioria (2010) conducted a study to validate the effects of a 4-week (1hr, 2 x week) formal auditory training program in adult hearing aid users with mild to moderate sensorineural hearing loss via a double blind randomized control trial. Fourteen bilateral hearing aid users were randomly divided into two groups: 7 receiving auditory training and 7 who did not. The auditory training program consisted of pointing to sentences, figures, digits, verbal repetition, and humming temporal patterns. These exercises were performed both monaurally and binaurally. Post-training evaluations included a standard behavioural auditory processing evaluation, electrophysiological measures, and a self-report questionnaire.

The results of this study revealed that formal auditory training caused a decrease in P3 latency, improved performance in behavioral measures, and higher hearing aid benefit in noise. A weakness of this study was that it contained a small sample size, which decreased the statistical power of the results. A larger sample size would provide better representation of the interventions effect on the entire population. The major strength of this study was that it employed a double blind RCT, the gold standard. The control group gave the experimenters more confidence that improvement was likely due to AT rather than other factors. In addition, the randomization of participants and blinding reduced experimenter bias.

Prospective Ranomized Control Trial

Burk and Humes (2009) conducted a prospective randomized control trial (repeated measures group design) to evaluate the usefulness of an 8 -12 week word-based auditory training protocol for older adults with hearing impairment. Two different computer-based training programs were used to present word stimuli in the presence of background noise. The stimuli consisted of open set word recognition testing of: frequent words, frequent phrases, Veterans Administration Sentence Test (VAST) and CID sentences. The pre and post training assessment tools consisted of closed set identification of five different measures: CID everyday sentences, CID everyday sentences 2, 200 randomly selected frequent word stimuli, 200 modified VAST sentences, and 376 frequent phrases.

Results indicated that the word- based training programs were efficacious for older adults with impaired hearing under the specific conditions used in

the research laboratory. The greatest improvement (21.7%) from baseline was measured in the frequent word stimuli evaluation ($p<.05$). Smaller, but significant improvements were also measured in the remaining post training evaluations.

A major weakness of this study was that it did not contain a control group and therefore, improvements from baseline could not be confidently attributed to treatment effect. In addition, the authors of this study did not thoroughly explain how the participants were separated into the various treatment groups. The strength of this study is that it used ANOVA and t-tests to establish statistical significance and ensure that extraneous factors were not influencing test results.

Critical Review

The purpose of the critical review by **Brouns et. al. (2010)** was to assess whether AT could improve speech discrimination in adults with mild-moderate SNHL. A review of the research yielded 6 studies that supported the use of auditory training to improve speech discrimination. Three of the studies were non-randomized observational case control, two of the studies were RCT's, and a systematic review of the evidence was included. The main criticisms of these studies were modest treatment effect sizes and lack of large sample randomized control trials. Brouns et. al. (2010) clearly stated the purpose of the review article and how they formed a critical evaluation of their clinical question. Internal and external validity, as well as inclusion/exclusion criteria, search strategy, and outcomes measures were adequately described and allowed them to formulate conclusions about their clinical question.

A strength of this paper was the evaluation of the statistical analysis employed by the studies that were included. The authors were able to confidently make conclusions on the effectiveness of AT. Brouns et al. (2010) concluded that implementing an auditory training program could be beneficial for rehabilitation of adults with hearing impairment. They did however find methodological weaknesses and modest clinical outcomes

Conclusion

It can be seen from the current review of the literature that, for adults with mild to moderate sensorineural hearing loss, auditory training did provide improvement for the various behavioural measures included in each of the studies and therefore it could be a useful addition to traditional hearing aid fitting. The results of this review also showed that the effects of an auditory training program could be retained for up to 14 weeks post training and that material learned could be generalized to novel talkers. In addition, Stecker et. al (2006) found that AT could provide benefit over an above conventional hearing aids. The overall qualitative level of evidence in this critical review suggested that the results were compelling. These results should be interpreted with caution before implementing auditory training protocols clinically because there were some methodological limitations in each of the studies reviewed such as lack of control groups, small sample sizes, and modest treatment effects.

The evidence suggests that auditory training in adults with mild to moderate hearing loss is promising, but unfortunately there is a lack of consensus on training protocol. This limits the application of the current research into clinical practice. Future research should focus on evaluating different types of AT and assess the patients that are most likely to benefit the most from this type of rehabilitation. In addition, as noted by Burk and Humes (2008), developing outcome measures that are clinically relevant is crucial for future research. Although all of the studies found improvements on various behavioural measures, the results obtained may be limited to the specific AT techniques and outcome measures used in the study. For example, Burk and Humes (2008) found improvements on word recognition score with AT yet these results did not generalize to more clinically relevant tests using running speech.

The idea of providing the patient with resources in addition to conventional hearing aid fitting is not a new one. Aural rehabilitation programs and counseling sessions have been implemented clinically with successful outcomes. Even though the results of this clinical review revealed a lack of consensus on training protocol, it did reveal the benefits of AT over the fitting of hearing aids alone, as well as long term retention of benefits. This information can be used to support the use of AT as a part of aural rehabilitation programs and to drive further research regarding specific protocols and real world outcome measures.

Clinical Implications

Currently there are various PC-Based auditory training protocols available for the public to access online. These training packages could potentially be used in the future as a means for audiologists to supply auditory training to their patients via a self-paced program that could be completed at home. These programs could save time for audiologists and provide the patient with additional resources to overcome problems listening in situations where there is a reduced SNR.

The results of this critical review are encouraging for providing such services for patients but there is not enough convincing evidence to suggest that audiologists should recommend AT in addition to fitting of amplification for adults with mild to moderate sensorineural hearing loss. Consensus on protocols and real world benefit needs to be further investigated before AT can be implemented clinically.

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References

Bode, D.L. and Oyer, J.J. (1970). Auditory training and speech discrimination. Journal of Speech and and Hearing Research, 13, pp.839-855.

Brouns, K., Refaie, A.E., and Pryce, H. (2010). Auditory Training and Adult Rehabilitation: A Critical Review of the Evidence. Global Journal of Health Science, 3(1), pp 49-63.

Burk, M. H. and Humes, L.E. (2008). Effects of long-term training on aided speech-recognition performance in noise in older adults. *Journal of Speech,Language, and Hearing Research*, 51 (3), pp 759-771.

CASLPA (2005). Adult Hearing Disorders. http://www.caslpa.ca/PDF/fact%20sheets/adult%20hearing%20disorders.pdf

Gil, D. and Ioria, M.C.M. (2010). Formal Auditory Training in Adult Hearing Aid Users. Clinics. 65 (2). pp165-174.

Humes, L.E., Burk, M.H., Strauser, L.E., and Kinney, D.L. (2009). Development and Efficacy of a Frequent-Word Auditory Training Protocol for Older Adults with Impaired Hearing. *Ear and Hearing*, 30 (5), pp 613-627.

Kricos, P.B. (2006). Audiologic Management of older adults with hearing loss and compromised cognitive/psychoacoustic auditory processing capabilities. *Trends in Amplification*, 10 (1), pp 1-21.

Stecker, G.C., Bowman, G.A., Yund, E.W., Herron, T.J., Roup, C.M. and Woods, D. L. (2006). Perceptual training improves syllable identification in new and experienced hearing aid users. *Journal of Rehabilitation Research and Development*, 43 (4), pp 537-552.

Statistics Canada. (2006). Participation and Activity Limitation Survey 2006 Facts on Hearing Limitations. Social and Aboriginal Statistics Division. Catalogue no. 89-628-X 2009012

Studebaker, G. (1985). A "rationalized" arcsine transform. *Journal of Speech and Hearing Research*, 28(3), pp 455-62.

WHO, (2010). Deafness and Hearing Impairment. http://www.who.int/mediacentre/factsheets/fs300/e