

Auditory Training in Speech Recognition and Hyperacuity



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Abstract

Background: There can be a significant reduction in quality of life as a direct result of people suffering hearing impairment as this affliction can affect everything from individual safety to inner ear balance. However, new technological developments have further advanced the available solutions for those suffering from hearing impairment.

Objectives: This analysis set out to review what role auditory training might have in clinical practice as a method to reducing hearing difficulties for hearing impairment patients. While auditory training has been a rehabilitative concentration in the empirical research, this analysis suggests that there exists the possibility of improving hearing through hyperacuity.

Methods: In attempting to prove this hypothesis, this analysis pursued a bilateral research approach to investigate the existing literature on the subject. Firstly, an extensive literature review about hearing impairment took place. The second part of the bilateral approach was a case study on two different experiments directly related to auditory training programs. For variation, one was chosen on the use of auditory training programs on adults, while the second was chosen to investigate the effect of auditory training on children.

Results: The case studies determined that auditory training had positive effects on their participants when compared to their respective control groups. Shoemaker [1] proved auditory training's ability to deliver hyperacuity by presenting the improved listening scores of a group of children with no hearing problems after a round of auditory training. While not conclusive, the study does show that there is extensive evidence about auditory training and the benefits it can provide to patients suffering from hearing loss.

Keywords: Prebyscusis; Central auditory processing disorder [CAPD]; Auditory training; Auditory rehabilitation; Hearing impairment; Audiological; Auditory training programs and auditory processing

Introduction

For those suffering from hearing impairment, there can be a significant reduction in quality of life as a direct result of their affliction. As a primary sense, hearing impairment can affect everything from individual safety to the inner ear balance. Depending on how an individual comes to suffer from hearing impairment, an assortment of complications could further afflict patients down the line, leading scientists suggest that the aural connections to auditory cognitive processing is still far from being fully understood [2]. Conventional solutions to hearing impairment have typically taken the form of hearing aids and, in more complicated approaches to solving the issue, surgically implanted cochlear implants. These solutions have been a mainstay for decades, but new technological developments have further advanced the available solutions for those suffering from hearing impairment.

These new advances might provide excellent tools in the ongoing work to alleviate the lives of those individuals suffering from hearing impairment. Auditory Training represents one such avenue of auditory rehabilitation without the prerequisite use of assistive listening devices such as hearing aids or cochlear implants. Developed as a means of harnessing the audible perception left for those with hearing impairment, auditory training is, in effect, a series of exercises that teaches patients to suppress noise on which they do not wish to concentrate, while focusing the information on with they do. Much of the research on the subject, however, indicates that results are still absent, specifically due to a lack of empirical research.

While several studies have been conducted on the practices and benefits of auditory training, clinicians and practitioners have yet to employ the technique on a mass scale. More importantly,

the advent of at-home and internet-based auditory training programs suggests that a commercial market is growing for these programs as patients suffering from hearing impairment seek to find cost effective solutions for their affliction.

Statement of the Problem

This analysis will look to answer what role auditory training might have in clinical practice as a method to reducing hearing thresholds for hearing impairment patients. To do so, it is expected that, while results will be inconclusive regarding the total effectiveness of auditory training, initial research will reveal that the training is beneficial to patients suffering from hearing impairment, and represents a valid alternative for auditory rehabilitation.

Study Background

Hearing loss is an affliction that can occur for many different reasons and from various origins. Congenital and neonatal hearing loss develops at birth from either infection or from birth defects. Hearing loss also occurs from external stimuli such as in noise-induced hearing loss (NIHL), trauma, or temporary threshold shift, where noise exposure can lead to permanent or temporary hearing loss. Presbycusis is associated with the natural progression of time as it is the changing of the cochlea resulting from ageing. However, many of these are just a few possibilities for hearing loss. Ototoxicity or viruses and bacteria, both represent external stimuli, which have nothing to do with noise levels that can lead to temporary or permanent hearing loss. These represent a foreign body introduced into the host which can be detrimental to the functioning of the ear and impair hearing. More severe afflictions can arise as well, such as tumors within the ear that can impair hearing. Ultimately, hearing and auditory processing are a delicate physiological system that might never develop, dissipate over time, or vanish in an instant. Understanding the nature of hearing and hearing impairment are critical to treat and improve quality of life for those suffering from hearing impairment.

Hearing and the auditory cortex has yet to be fully understood [3]. Because of the complex neural activity that follows auditory stimulus, it becomes increasingly difficult to fully understand how audiological cognitive processing takes places. Breakdowns in this system are defined as an affliction of (Central) Auditory Processing Disorder [(C)APD] which is defined as “the efficiency and effectiveness by which the central nervous system utilizes auditory information” [4]. Disorders of this nature are associated with “difficulties in listening, speech understanding, language development, and learning, but in its pure form, it is conceptualized as a deficit in the processing of auditory input” [4]. Auditory training provides an excellent alternative to treat a complex issue with myriad symptoms and variants. Auditory training is a series of listening exercises and activities that help to facilitate the perception of speech, sounds, and other audial stimuli. Exploiting the hearing mechanisms in the ear allows

for patients undergoing auditory training to suppress audial stimuli they wish to ignore while concentrating on the stimuli on which they wish to concentrate. This is done through exploiting the existing capacity for hearing, typically following the use of conventional hearing aids or some other apparatus, to harness the information provided to them by what auditory signals they can still perceive.

Methodology

A bilateral qualitative study will be conducted about hearing impairment and how auditory training interacts with its afflictions and treatment. The first will be a review of the literature as produced by leading researchers and experts on the subjects. The review mainly consists of clinical studies on auditory training conducted on participants both with and without hearing impairment to document the generalized benefits arising from the training. The second will be in-depth case studies of two experiments on auditory training. The use of case studies in this instance allows for explorative comparisons or benefits in known cases.

The study is a qualitative review on the prevailing, academically published material regarding auditory training and the treatment of patients suffering from auditory training. The studies were selected for this review to study many different issues. The first issue relates to the current conditions surrounding audiological and hearing impairment. These articles provide context on both the problem identification of this issue as well as what solutions, by-and-large, exist to assist patients with hearing impairments. The second issue is that of new technological solutions currently under development to address the issues of hearing and audiological impairment. These include devices such as haptic wearable devices or frequency transposition technology. Understanding the nature of new technologies for treatment of patients suffering from hearing impairment may provide avenues through which auditory training may be better applicable. The third issue to be studied are the effects of auditory training, both in standalone programs or in conjunction with technological devices. Discussed will be aspects, methods, and iterations of auditory training and interaction between auditory training programs and the technology with which these programs will interact.

Review of Related Literature

Current conditions and solutions

Hearing impairment has seen many solutions presented over the years. While many solutions have been through scientific research, commercial activity is a driving factor in many, if not all, medical advancements in recent history. Grove & Fisk [5] suggest that the hearing-impaired population represents an important and lucrative market for American businesses and they argue, this should contribute to “better serving healthcare needs” The business community should be aware of what devices, programs,

and options are available, as auditory training might avoid some of the complications associated with conventional hearing impairment solutions [5].

Gheorge & Zamfir-Chiru [6] document the complications that can arise from cochlear implant surgery and provide suggestions as to how best avoid those. The authors suggest that clinicians should ensure that the solutions they present to patients are safe and that the clinician can be trusted with valid solutions. Communication and trust are integral in both the procedures presented to the client as well as the patient relationship. Laplante-Levesque [7] explores the nature of the patient-clinician relationship to better explain what is required for successful treatment. The study suggests that clinicians should further discuss the self-reported degree of hearing disability among patients that will allow for the uptake and success of intervention methods [7].

Lidström & Hemmingsson [8] explored the effects that information and communication technology (ICT) have on hearing loss and attempts to explain how ICT is being used by students with disabilities and what effect it is having through a literature review. The study was successful in confirming the positive impact that ICT has for impaired students at-large. These devices may be effective tools at a moderate level that allow for low-range stimulus without the invasive options of surgical implants. Furthermore, Rishiq Rao et al. [9] attempt to determine whether the combined use of computer-based auditory training and hearing aids have a noticeable advantage over simply using hearing aids to improve audiovisual performance. Their findings suggested that there was no discernible effect of the RMQ program after 4 weeks testing. However, that does not determine whether auditory training in and of itself is without merit. Much of available evidence suggests that, while auditory training can contribute to increased auditory performance, the type and application of the training is equally as important as the presence of the training itself.

While the programs can be successful in achieving some levels of auditory rehabilitation, the approach must be personalised to the individual patient to ensure that their treatment specifically targets the issues with which they are suffering. For this, sometimes parents are the best variable in ensuring the success of the treatment and the rehabilitation of auditory senses. Ensuring that children continue to use their hearing aids is instrumental to confirming engagement in the rehabilitation process while minimising any undue stressors [10]. In the end, ensuring that the right hearing aids are applied to the correct patient may be the difference between a successful treatment and one characterised by failure [11].

For example, Kim's [11] study and critical review on the superiority of Bone Anchored Hearing Aids in comparison to Air Conduction Hearing Aids for patients suffering from conductive and mixed hearing loss indicates that Bone Anchored Hearing Aids are proven to provide equal, if not better, hearing aid

performance than Air Conduction Hearing Aids. Additionally, patients clearly indicate that they prefer Bone Anchored Hearing Aids to the Air Conduction variant [11].

New approaches and technology

Dubno [12] conducted a study on two developing auditory training programs for older adults suffering from hearing impairment. The first program, developed by Indiana University is a word-based training program, while the second one is the Speech Perception Assessment and Training System (SPATS) [12]. The results were successful in deriving improvements for recognition of various metrics, including sentences, words, phrases and trained sounds, but varied from case to case. However, the study did provide some evidence regarding the potency with which auditory training supplanted aided listening. Furthermore, the presence of new systems suggests that practitioners and theorists are embracing auditory training programs that depart from the conventional route of hearing aids and other assisted listening devices. Training programs are important because they work to improve patient's hearing instead of managing the damage.

In another approach, Abraham & Surya [13] attempted to prove the effectiveness of frequency transposition in digital hearing aids to facilitate the reception of low-frequency speech cues. These results indicate that the authors' algorithm is successful in facilitating the detection of words through increased speech cues- suggesting that the technology is ripe for greater research as a means of facilitating hearing recovery.

Furthermore, Shull & Damian [14] studied haptic wearables as a sensory replacement for patients who suffer from sensory impairment [14]. They suggest that, to help alleviate quality of life deficit from sensory impairment, practitioners should explore the use of wearable electronics that use haptic feedback to assist in both rehabilitation and ongoing alleviation of impairment. This would be an effective tool as the sound and haptic frequencies may align more easily than for other impairments.

With research like this, researchers may find novel ideas for administering auditory recovery [12]. For example, Tye-Murray [15] suggests using customisable video games to tailor the treatment of hearing impairment and highlights the benefits of use in customised Learning. The cLEAR program "incorporates the speech of someone [the patient] knows, supporting successful everyday conversations" [15]. This is an effective approach to treating hearing impairment and allows audiologists to gain an advantage on the inexpensive hearing aids currently available in the market. Following up on the subject, Tye-Murray & collaborators [16] found that a frequent communication partner has a huge impact on the auditory training process to improve patients' speech recognition. These partners typically are a loved one; a spouse, family member, or friend. The results were overwhelmingly positive. Participants in the training could overcome communication difficulties and

discriminate speech better after the training. This shows that the training can be effective in teaching patients to suppress noise and focus on a single rhythm. Moreover, new programs such as this encourage the sale of low cost commercial auditory training programs as well [16].

For example, Abrams et al. [17] studied whether a remotely-delivered, internet-based system can successfully improve speech-in-noise recognition while cutting cost. The authors suggest that remotely-delivered, internet-based auditory training programs can provide an alternative to clinic-based interventions, but suggest that the method can have poor compliance. Never the less, the internet is one of the best tools clinicians have in finding new paths for treatment of patients not only for efficacy but for reach and accessibility to target populations. Thorén et al. [18] studied the usefulness of the internet in auditory training and conclude that the internet can prove an effective tool in auditory training, however, consistency appears to be the key to successful treatment as noncompliance with treatment can be detrimental to success [18].

Wilson et al. [19] conduct an extensive literature review on the effectiveness of electrophysiological tools for school-age children that suffer from (central) auditory processing disorder ([C]APD) which yielded limited evidence that AT leads to measurable electrophysiological changes in children with auditory processing deficits. However, click-evoked AMLR and tone-burst evoked auditory P300 might be more likely to detect such outcomes in children diagnosed with (C) APD, and that speech-evoked ALL R might be more likely to detect phonological processing changes in children without a specific diagnosis of (C) APD [19].

Standalone auditory training

Shoemaker [1] found a clear improvement in auditory processing skills in the two groups receiving the dichotic auditory training which shows it is an effective tool in auditory rehabilitation in central auditory processing disorder. With these types of results, hyperacuity as auditory training can actively increase the patient's ability to hear beyond their original threshold [1].

Barcroft et al. [20] conducted an extensive study into the effects that task and talker overlap tests in auditory training programs have on speech perception on adults with hearing loss [20]. While the evidence indicates that transfer-appropriate processing in auditory training is effective, it is more so when a program is tailored to an individual's specific needs for tasks, talkers, and stimuli which is critical to success [21].

Öberg [22] attempts to develop a new form of audiological rehabilitation for those suffering from chronic hearing loss to try to reduce audiological impairments. The results indicate that the audiological rehabilitation program introduced by Öberg was successful. Talebi et al. [23] conducted a clinical trial to determine auditory training's impact on concurrent speech segregation in small children. The results of the trial provided

strong evidence for auditory training as an effective tool in treating children.

Kishon-Rabin et al. [24] measured the improvement in gap-detection tasks following the application of various auditory training sessions with an added comparison between younger and older adults and concluded that auditory training is not only an effective means of treating hearing loss, but can also improve plasticity in older adults even without the presence of hearing loss. Sommers et al. [21] studied whether auditory training could help reduce perceptual or listening effort, as well as improve speech intelligibility. The authors surmise that the auditory training program was effective in reducing perceptual effort as well as improving intelligibility. These two improvements are the most critical to slowing hearing impairment. Lavie et al. [25] investigate whether auditory training with amplified, clear speech in regular room acoustics yields significant gains in elderly hearing aid users' auditory processing and conclude that listening training is effective in producing better results in the dominant ear, which they state is the ear least likely to show improvement.

Auditory training in conjunction with other apparatus

Schumann et al. [26] set out to identify what contributions computer-based auditory training programs can make to rehabilitating listeners using cochlear implants and found that phoneme-discrimination programs are effective in improving the speech perception in noise for cochlear implant listeners. The improvements in sentence recognition while combatting moderate noise levels may represent the first step to a more moderate hearing capacity. Hassan et al. [27] argued that a modified computer-based Arabic Rehabilitation Program is effective in improving auditory abilities as well as speech intelligibility.

Murphy et al. [28] document the case of a Brazilian man who began to have difficulty understanding speech. The treatment induced plasticity, with improvement in auditory abilities and a generalisation of that improvement to cognitive abilities. Chisolm et al. [29] examined computer-based auditory training in Veterans using hearing aids by employing the Listening and Communication Enhancement (LACE) program. The authors set out to determine whether performance in speech perception improved over the course of auditory training and found that compliance played an integral component in the success of auditory training.

Compliance becomes a significant factor when assessing AT as a treatment method. Patient compliance with training and connected treatment show a positive relationship with improvement, however, compliance is limited [30]. Sweetow et al. [31] found that more than sixty-six percent of the patients were non-compliant in a Listening and Communication Enhancement (LACE) program. Controlling the patient becomes a necessary component of the process, however, auditory response is a rare category relating to non-compliance.

Study cases

The case studies presented after the review allow for more nuanced and thorough studies of individual trials as conducted by leading clinicians. The importance of these studies stands out thanks, in part, to their comprehensive approach and concrete conclusion presented. By completing in-depth case studies on this experiment, the conclusions drawn from their studies can contribute to the overall argument regarding auditory training's efficacy in treating hearing impairment [31].

Case study 1

The first study aims to examine the "behavioural effects of an auditory training program called Listening and Communication Enhancement (LACE) in the Digital Video Display (DVD) format in new and experienced hearing aid users" [31]. Olson [31] develops the hypothesis to test the research questions and predict the outcome based on the literature review. Each hypothesis has been presented to assess moving forward with the respective case study, examining the effectiveness of the DVD toward auditory training.

Hypothesis 1a: New HA users "will obtain greater improvement in understanding speech in noise after 4 weeks of training compared to experienced HA users" [31]. Further, new HA users who receive the training will obtain greater improvement "in understanding speech in noise compared to new HA users in the control group who do not receive the training" [31].

Hypothesis 1b: New HA users will "obtain greater improvement in understanding rapid speech after 4-weeks of training compared to experienced HA users" [31]. This component of the hypothesis is relatively straight-forward, where those who receive the training are more likely to find benefit in the training, particularly compared to those who receive no training at all. Further, there is no difference in the ability to understand rapid speech when comparing the new users in the treatment group and those in the control group.

Hypothesis 1c: The hypothesis suggests that new HA users will obtain "greater improvement in understanding competing speech after 4-weeks of training compared to experienced HA users" [31]. Hypothesising that competing speech will improve for those who are new to the training as compared with those who have established themselves in the training program is aligned with the former hypotheses that suggest speech patterns are going to show more improvement for those who are new to the program. Those who have already been a part of the program lack the rapid improvement and growth that is evident with one who is in the beginning stages of the program.

Hypothesis 2: It is hypothesised by Olson [31] that "most of the improvement from DVD training program would occur in the first 2-weeks of training and that performance would essentially plateau for both new and experienced HA users in the trained groups after an additional 2-weeks of training" (p. 7). Whereas

the training program is effective during the initial 2-week period, there is no need to continue the training after 2 weeks as the advancement will be non-existent.

Hypothesis 3: The third hypothesis finds that participants in either training group will perceive "small, but significant improvement in functional communication abilities based on self-assessment after training" [31]. The hypothesis is making the claim that individuals will not find significant improvement in hearing at the end of the 4-week training course, making this an obsolete training method for improving hearing and functionality.

Hypothesis 4: The fourth hypothesis claims that there "may be differences in the perception of amount of benefit from training between groups and participants" [31]. The idea behind the hypothesis is that the user will respond to something that is new, believing that there is benefit because of the new methods that are presented with this training DVD. However, once the user continues with the training, and it is no longer perceived as new, the benefits will be perceived as limited, and eventually obsolete.

Hypothesis 5: Working memory "will contribute significantly to explaining the amount of benefit obtained by participants in the training groups" [31]. This hypothesis explains why there will be benefit in the immediate use of the training program, but limited benefit moving forward. However, Olson [31] suggests that the variance explained by regression analysis will not change depending on whether there is working memory or not working memory in the model.

Results of the Case Study

H1a: The results did not support the hypothesis related to this question. In the trained group, new HA users "did not obtain significantly greater improvement in speech understanding in noise compared to experienced HA users" [31]. All three groups (new HA, experienced HA, control group) "improved on the speech in noise task" as there were no significant differences across the groups [31]. However, the new users did demonstrate the most significant improvement in dB SNR, out of all the groups.

H1b: Results from the Compressed Speech test did not support the hypothesis related to Question 1b. "The percentage of correct words increased from pre-test to post-test for all groups on the Compressed Speech test" [31]. Several possible explanations exist for these findings. The general understanding is that training on rapid speech will require a lengthened period of evaluation. The present version of LACE™ does not recognise this tenured approach to observation, and does not allow the study to fully evaluate the potential of the program in this regard. Therefore, an extended version would likely be necessary to support the hypothesis and suggest that those who are in the initial stages of this component of the training are going to find an enhanced level of success, as compared with the non-new users [31].

H1c: The results from the SSI do not support the hypothesis related to Question 1c. “There was not a significant difference between trained groups in their ability to identify competing sentences because performance improved by approximately 10% in both groups” [31]. There were no statistical group differences found, despite a significant interaction with the ANOVA analysis.

H2: The results from this question support hypothesis 2. However, there is partial support for this hypothesis, where New HA users + training “demonstrated significant gains in speech understanding after 2-weeks of training” [31]. The additional 2 weeks “did not result in additional improvements for understanding speech in noise for the new users” [31]. Therefore, the hypothesis for this question proves that there is an essential stoppage period where the benefits will no longer be aligned with the training. Experienced users were not finding any significant improvements after the 2-week period, but did show a significant training effect after 4-weeks. Thus, the hypothesis is only partially supported because there is improvement after 4-weeks, despite the lack of improvement after the 2-week period.

H3: Results from the SSQ partially support the hypothesis. “There was significant improvement for both sub scales of the SSQ between baseline and 4-weeks” [31]. Still, there was no significant difference between groups from baseline to 4-weeks for either the Hearing Speech or Qualities sub scale [31]. The most critical finding as connected with this question and associated hypothesis is that there was significant improvement in both trained groups as compared with the control group that did not show any improvement due to a lack of training, and no participation in the program [31]. This hypothesis is partially supported as the trained group showed more improvement as compared with the control group.

H4: The results would support this hypothesis. “New HA users reported greater perceived benefit after training compared to the experienced users” (Olson, 2010, p. 88). One of the findings is that effective training may take place in a home setting. This is an encouraging initiative for individuals with hearing loss and Has, as it “underscores the potential that additional benefit exists from training that occurs at home rather than in a clinic” [31]. Supporting the hypothesis under this question examines the benefit of New HA users and their ability to adapt to the program and connected treatment, increasing their speech and listening techniques through direct use of the program.

H5: Working memory decreases with age. This was considered a surprise based on the study [31]. The “weak negative relationship between working memory and age observed in the present study is inconsistent with previous research” [31]. That is, the findings of this study went against prior research on the subject matter, suggesting there is a disconnect between the Literature Review and the findings of this study. One possibility

is that the RSPAN Test is “not sensitive to the age-related changes that are typically observed” [31]. This was a challenging task for many of the participants, which may have burdened the study and the connected results. RSPAN scores may have been lower than those obtained in the present study if there were any issues with the test, which is considered challenging by participants.

Case study 2

Shoemaker [31] and colleagues stress that more research is needed to determine the efficiency of treatment procedures. Therefore, this case study by Shoemaker [31] looks to investigate the impact of novel therapeutic procedures such as Dichotic Auditory Training (DAT) on abilities of auditory processing in children. Shoemaker [31] focused on the potential benefits of novel training technique development for the management of (C) APD [31].

The developed program was a unique combination of a “systematic presentation of a series of dichotic monosyllabic words designed to stimulate directly and develop a specific auditory process: channel separation. In the development of this experimental treatment, the stimuli are designed to increase in difficulty progressing from an easy task to a more difficult presentation over the period of eight 45-minute individual sessions lasting for one month [31].”

Hypothesis 1: Children receiving the DAT will have significant improvement on the developed pre/post-DAT Screening Tool post-treatment. In addition, children receiving the DAT will have a significant improvement in the overall percentage of the post-DAT. Children receiving only pre- and post-testing will not have significant improvement on any of the conditions of the DAT or overall percentage on the post-DAT [31].

Hypothesis 2: Children receiving the DAT will have significant improvements on the following post-treatment conditions on the SCAN-Children/Adolescents and Adults:

- A. Test of Auditory Processing Abilities {SCAN-C/A}:
- B. Auditory Figure Ground for the left ear (AFGL),
- C. Competing Words for the left ear (CWL), and
- D. Competing Sentences for the left ear (CSL) [31].

Children receiving the DAT will not have significant improvements on the following post-treatment test results of the SCAN-C/A:

- A. Filtered Words for the right (FWR) and left (FWL) ears,
- B. Auditory-Figure Ground for the right ear (AFGR),
- C. Competing Words for the right ear (CWR), and
- D. Competing Sentences for the right ear (CSR) [31].

Children receiving only the pre- and post-testing will not have any significant improvements on any condition of the SCAN-C/A.

Hypothesis 3: Children receiving the DAT will have significant improvements on the post-treatment conditions of the Staggered Spondaic Word (SSW) test:

- A. Total number of errors (SSWTOT),
- B. Left Non-Competing (LNC), and
- C. Left Competing (LC) [31].

Children receiving the DAT will not have significant improvements on the following post-treatment conditions of the SSW test:

- A. Right Non-Competing (RNC)
- B. Right Competing (RC) [31].
- C. Children receiving only the pre- and post-testing will not have any significant improvement on any condition of the SSW [31].

Results of the case study

This was approved by the Louisiana Tech Institutional Review Board [31]. The findings of the current investigation supported the hypothesis that the DAT therapeutic intervention significantly improved dichotic auditory processing abilities in children with and without a diagnosis of (C) APD. First, while both groups of children receiving the experimental treatment improved significantly on the DAT Screening Tool, it was shown that the children with (C) APD improved significantly more than the children with normal auditory processing abilities. Shoemaker's DAT Screening Tool shows to be sensitive enough to detect improvements in children with and without (C)APD, which means that the procedure has the potential for benefit from malleability of a young auditory system [31]. A second finding is that the two groups of children with normal auditory processing abilities had similar performance on the pre-DAT Screening Tool; however, after receiving the DAT exercises, Control Group A improved significantly on the post-DAT Screening Tool and Control Group B did not. Another discovery was that children with (C)APD had poorer performance on the pre-DAT Screening Tool compared to children with normal auditory processing abilities. This new testing paradigm shows promise as a possible tool to assist with the differential diagnosis of children with (C) APD from those with normal auditory processing abilities [31].

Scope

The goals of this study are two-fold. Firstly, the study attempted to determine the validity and applicability of auditory training programs. Secondly, this study will add to the growing chorus of voices advocating the development, introduction, and implementation in hearing rehabilitation treatment. The goal is to contribute to the legitimacy and validity of auditory training, through research means, to allow for widespread acceptance and implementation in the field of audiological rehabilitation.

Significance of the study

The study is a qualitative review on the prevailing, empirical evidence regarding auditory training and the treatment of patients. The review of literature across the field allows for information to be gleaned from leading clinicians, practitioners, and theorists. Moreover, a critical review also provides a cost-effective solution to the high-priced costs associated with audiological clinical trials. In addition to a cost-effective solution, the review allows for the views and opinions of leading experts to be examined at a significantly higher rate, with more evidence from individual trials than could possibly be completed at such an introductory level.

Conclusion

Hearing impairment has seen many solutions presented over the years. The business community should be aware of what devices, programs, and options are available, as auditory training might avoid some of the complications associated with conventional hearing impairment solutions [5]. Clinicians should ensure that the solutions they present to patients are safe and that the clinician can be trusted with valid solutions. Communication and trust are integral in both the procedures presented to the client as well as the patient relationship and offering the best option for the patient is critical. Lidström & Hemmingsson [8] confirmed the positive impact that ICT has for impaired students as an effective tool. Other available evidence suggests that, while auditory training can contribute to increased auditory performance, the type and application of the training is equally as important as the presence of the training itself. Ensuring that the right programs are applied to the correct patient may be the difference between a successful treatment and one of failure [11].

For example, Bone Anchored Hearing Aids are proven to provide equal, if not better, hearing aid performance than Air Conduction Hearing Aids. Additionally, patients clearly indicate that they prefer Bone Anchored Hearing Aids to the Air Conduction variant [11]. Speech Perception Assessment and Training System (SPATS) Dubno [12] were successful in deriving improvements for recognition of various metrics, including sentences, words, phrases and trained sounds, but varied from case to case. In addition, a frequency transposition algorithm is successful in facilitating the detection of words through increased speech cues-suggesting that the technology is ripe for greater research as a means of facilitating hearing recovery. Wearable electronics that use haptic feedback to assist in both rehabilitation and ongoing alleviation of impairment would be an effective tool as the sound and haptic frequencies may align more easily than for other impairments. Customizable video games are another viable option as it and allows audiologists to gain an advantage on the inexpensive hearing aids currently available in the market.

Research also shows that frequent communication partner has a huge impact on the auditory training process to improve patients' speech recognition. Training in this approach could overcome communication difficulties and discriminate speech better after the training. This shows that the training can be effective in teaching patients to suppress noise and focus on a single rhythm. Moreover, new programs such as this encourage the sale of low cost commercial auditory training programs as well.

Remotely-delivered, internet-based auditory training programs can provide an alternative to clinic-based interventions, but there should be complete compliance measures involved for it to be successful. Furthermore, electrophysiological tools for school-age children that suffer from (central) auditory processing disorder ([C]APD) yielded limited evidence that AT leads to measurable electrophysiological changes in children with auditory processing deficits. However, click-evoked AMLR and tone-burst evoked auditory P300 might be more likely to detect such outcomes in children diagnosed with (C) APD, and that speech-evoked ALL R might be more likely to detect phonological processing changes in children without a specific diagnosis of (C) APD [19].

Shoemaker [1] found a clear improvement in auditory processing skills in the two groups receiving the dichotic auditory training which shows it is an effective tool in auditory rehabilitation in central auditory processing disorder. The effects that task and talker overlap tests in auditory training programs have on speech perception on adults with hearing loss is that transfer-appropriate processing in auditory training is effective, it is more so when a program is tailored to an individual's specific needs for tasks, talkers, and stimuli which is critical to success.

An audiological rehabilitation program introduced by Öberg [22] was successful for those suffering from chronic hearing loss to try to reduce audiological impairments and auditory training program was effective in reducing perceptual effort as well as improving intelligibility. Auditory training yields significant gains in elderly hearing aid users' auditory processing and conclude that listening training is effective in producing results as well as modified computer-based Arabic Rehabilitation Program in improving auditory abilities as well as speech intelligibility. The only drawback was that all must have complete compliance.

The first case study did not show support for the first of the hypothesized claims. However, it did show support where hypothesis 2 claims that New HA users + training "demonstrated significant gains in speech understanding after 2-weeks of training" [32]. However, after the two weeks, there is stoppage of improvement. "New HA users reported greater perceived benefit after training compared to the experienced users" [32]. However, hypothesis 5 countered the theory that working memory decreases with age. The second study results supported the hypothesis that the DAT therapeutic intervention

significantly improved dichotic auditory processing abilities in children with and without a diagnosis of (C) APD [4].

Concluding statement

This study determined that auditory training programs contribute to the legitimacy and validity of auditory training, through research means, to allow for widespread acceptance and implementation in the field of audiological rehabilitation for populations who suffer from hearing loss or afflictions.

Recommendations

While the effectiveness of individual auditory training has yet to be concretely evidenced, there are many contributions such as opening for the need for evidence-based research with strict adherence to scientific criteria, determining optimal outcome measures and optimal training parameters, and establishing cost-effectiveness. Nonetheless, there is confidence that auditory training is effective in improving hearing for those patients suffering from hearing loss, and that providing evidence to convince hearing health care professional will allow for its use in treatment. Based on scientific evidence, research suggests that there is concrete evidence indicating that auditory training is effective in improving speech perception and that better pre-selection for auditory training candidates might be beneficial to determining for whom the training might best work. Not only does this contribute to the field's legitimacy, but it ensures that patients who will benefit from the treatment with effective approaches for hearing loss [33-45].

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