Auditory Training and Adult Rehabilitation

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ABSTRACT

Background: Hearing loss is one of the leading disabilities. Its incidence increases with age, and it is associated with health and financial losses. Several solutions have been developed to fight against hearing loss, most notably, hearing aids. Although hearing aids such as cochlear implants restore hearing capacities among the users, they do not restore speech perception, and the people who use them continue to struggle with their speech and communication. To counter this problem, audiologists have developed auditory training and rehabilitation programs which enhance the ability of hearing aids users to perceive speech.

Purpose: The purpose of this Master's thesis was to explore the empirical available information in literature related to auditory training, review in deep, and use that information to generate best recommendations for optimal outcomes with auditory training. Method: The thesis used literature review research design and methodology to synthesize the information and draw conclusions and recommendations for the best practices in auditory training.

Findings: Auditory training is effective in enhancing speech perception and communication skills among hearing aids users. The outcomes of auditory training are not influenced by the distribution of training sessions over a short or a long period, as long as the number of sessions is equal. Different tests and measures are available to assess the effectiveness of auditory training. The impacts of training can be seen as soon as one week, although some training can be conducted for up to twelve weeks. Internal factors such as psychosocial characteristics may influence the outcomes of auditory training.

Conclusion: To optimize the outcomes of auditory training and rehabilitation, audiologists should account for all patients' needs and factors that influence the training.

INTRODUCTION

Backgraound

Hearing loss and deafness is an important health problem that affects many people globally. Approximately, 466 million people in the world have a form of disabling hearing loss, which is approximately 5% of the entire global population (Schmucker, Motschall, Loehler, & Meerpohl, 2019). The hearing loss and deafness health problem is expected to grow bigger, because in 2050, it is estimated that it will have increased by almost 100%, with more than 900 million people in the world suffering from it. Adults are the ones mostly affected by the problem because about 432 million people affected by this problem are adults while the remaining 34 million are children (WHO, 2020a).

Hearing loss occurs when one or more of the many parts of the ear are not functioning as expected. The parts that could be affected include the outer, middle, or the inner ear, the acoustic nerve, and the auditory system (Centers for Disease Control and Prevention (CDC), 2020a). Cruickshanks et al. (1998) and the WHO (2020a) define hearing loss as a condition in which a person is incapable of hearing as well as a person who has normal hearing, that is, a hearing Kapp, threshold of 25 dB or higher in both of their ears. Hearing loss varies in severity, it can be mild, moderate, severe, or profound, depending on the affected individual's hearing threshold.

There are several different causes of hearing loss and deafness. Genetics plays a major role in hearing loss because about 50% to 60% of hearing loss in children results from genetic causes (The Centers for Disease Control and Prevention, 2020b). Other non-genetic congenital causes of hearing have been reported. They include maternal infections such as rubella and syphilis, low birth weight, asphyxia at birth, inappropriate use of ototoxic medicines during pregnancy such as aminoglycosides, antimalarial drugs, and severe neonatal jaundice (World Health Organization, 2020a). The WHO also explains that some forms of hearing loss can be acquired at any age. The acquired causes include infectious diseases such as meningitis, chronic ear infections, otitis media, ototoxic drugs, head/ear injuries, excessive noise (including chronic exposure to occupational and recreational noise), ageing where sensory cells degenerate, and blockage of the ear canal by wax or foreign bodies.

Hearing loss is associated with many negative impacts. The most common negative impacts of hearing loss include inability to recognize speech, inability to communicate, and lack of language acquisition (Ohlenforst et al., 2017). Among the elderly, hearing loss is associated with impaired information exchange which impacts the quality of life by causing loneliness and isolation, dependence, and frustration (Ciorba, Bianchini, Pelucchi, & Pastore, 2012). Hearing loss is also directly related to distress, and decreased quality of life (Nordvik et al., 2018). These functional, social, and emotional impacts can cause distress and lower the quality of life, with the elderly being the most affected. Moreover, hearing loss is also associated with adverse economic impacts. In one year, the World Health Organization (2020a) asserts that hearing loss costs the world approximately 750 billion US dollars, without including the money spent on hearing aid devices, such as implants and others. Most of this money goes towards covering the healthcare costs and education support, while some of it is due to lost productivity.

Because of the negative impacts associated with hearing loss, many efforts have been put in place to prevent it, and even to correct it. Despite these efforts, there is no single treatment or prevention choice for hearing loss in children and adults. Some of the alternatives that are available for prevention and treatment of hearing loss include special education to improve communication, technological solutions such as hearing aids, implants (cochlear and brain), bone-anchored aids, and other assistive devices (Centers for Disease Control and Prevention, 2020c; Cook & Hawkings, 2006). Other approaches include infection prevention such as through immunizations against measles, rubella, and meningitis, healthy ear practices, reducing exposure to loud noises, screening for otitis media, educating young people and the general population about hearing loss and its prevention, among others (WHO, 2020a).

Problem Statement

Although the problem of hearing loss is significantly improved with the different forms of intervention available, problems with speech and communication may persist. Many patients request and acquire ear rehabilitation from audiologists, and mistakenly think that their main problem to correct is hearing loss. In reality, most of the hearing aids restore the audibility for many hearing loss patients, but the actual problem of communication is not directly connected to the satisfaction (Olson, 2015; Sweetow & Palmer, 2005). This happens because hearing is just the first stage in a series of events that result in communication.

Accordingly, researchers are coming up with new and different ways of improving communication among people who initially suffered from hearing loss. Auditory training is one of such innovations. Auditory training refers to a regimen that includes different listening exercises that are dedicated towards improving a person's ability to perceive and understand speech (Brouns, El Refaie, & Pryce, 2011). Malkan (2019) noted that auditory training fosters the development and enhances the ability to differentiate different properties of both speech and non-speech sounds. Therefore, auditory training teaches people with hearing loss and disabilities to use their residual hearing signals, and their brains, to listen. Because speech recognition, especially in unconducive listening environment, worsen with age, and even more in the case of people suffering from age related hearing loss (Karawani, Bitan, Attias, & Banai, 2016). Auditory training has elicited interest to see whether it is beneficial for the adult population.

Previously, auditory training has been tested and used in the process of rehabilitating elderly individuals to optimize their speech processing (Morais, Rocha-Muniz, & Schochat, 2015). Despite its wide application, its essential to evaluate and assess its effectiveness to differentiate it from placebo effects. Researchers who developed auditory training were guided by the theory of brain plasticity. The theory notes that neurons in the central auditory system adjust in their structure and physiological functionality following stimulation by audio signals, thus, improve audio and speech perception. This thesis is written to evaluate the actual effectiveness and application of auditory training and adult rehabilitation by examining available evidence from existing literature.

Current Status

Currently, auditory training and adult rehabilitation has received mixed reports. Some studies report about its effectiveness (Burk and Humes, 2008; Dubno, 2013; Humes et al., 2019; Karawani, Bitan, Attias and Banai, 2016; Moossavi, & Aghazadeh, 2019) while others recommend extra research to gather more evidence and counter the placebo effect (Henshaw & Ferguson, 2013; Stacey, 2010). In tests with a placebo, an intervention with no therapeutic value is designed and administered in a similar manner as the actual treatment, so that researchers establish the actual effectiveness of the intervention by comparing outcomes intervention and placebo outcomes. Therefore, researchers have continued to evaluate auditory training and rehabilitation among the elderly to determine its effectiveness. Despite the mixed findings, researchers agree that successful auditory training and rehabilitation requires the identification of individual patients' needs and creating specific goals for individual patients. Consequently, the British Society of Audiology (2016) has developed guidelines which recommend individual needs, specific goals, informed-decision making, and promoting self-management for all clients to overcome their daily difficulties. A lot of advancements have been achieved in auditory training from the older, verbal one-on-one training to computerized training (Ferguson & Henshaw, 2015a); which is easily individualized (Ferguson & Henshaw, 2015b).

Theoretical Foundation

The theoretical foundation that supports auditory training and adult rehabilitation is the theory of Neural Plasticity. It postulates that the human brain remains malleable from childhood all through to older adulthood (Anderson & Kraus, 2013). According to this theory, neurons in the auditory system can change their structures and functions as a result of audio stimulation (Brouns, El Refaie, & Pryce, 2011). It is essential to change the treatment algorithms, so that changes in learning that occur with age are addressed. Auditory plasticity is defined as the capacity and ability of structural (anatomical) as well as functionality changes occurring in the auditory system. In one study, it was established that the auditory system has plasticity. It reorganizes itself when a variation in sound stimuli such as a reduction, an increase, or its conditioning occurs (Kappel, Moreno, & Buss, 2011). Moreover, neural changes are reported alongside speech-in-noise and cognitive improvements. Therefore, Neural Plasticity Theory is applied in auditory training. Brouns, El Refaie, and Pryce (2011) explained how neural plasticity fosters auditory training. They noted that, when performed repeatedly, auditory training exercises make the neurons change structurally and functionally to form auditory neuronal pathways that are more efficient, thus, enhance the person's ability to process speech and discriminate speech from noise. In a different study, Yu et al. (2017) demonstrated changes on the auditory cortex, which were related to the use of hearing aids and auditory training. The study demonstrated changes in the superior temporal sulcus, a part of the brain that processes audio and visual signals. Therefore, Yu et al. (2017) provided essential data as evidence of neural plasticity related to experiencing auditory training.

Many other earlier studies have also supported the Theory of neural plasticity in auditory training. For instance, several authors (Russo et al, 2004, Tremblay et al, 1997, and Tremblay and Kraus, 2002), conducted neurophysiological studies where they used auditory-evoked potentials to demonstrate that changes occurred on the auditory cortex as a result of auditory training. Additionally, Brouns, El Refaie, and Pryce (2011) noted that sound neural encoding on the cortex of individuals with normal hearing abilities was altered by auditory training. This observation was important because it is believed that the miss match negativity represents activities that discriminate between different stimuli, while the N1-P2 complexes are involved in pre attentive stimuli. Hence, they are essential in evaluating processes that occur in the auditory cortex. Moreover, neural signals evoked by sessions of auditory training indicate a better functioning of the central auditory system and enhanced processing of signals in the system (Russo et al., 2004; Tremblay & Kraus, 2002).

Accordingly, improvements in measures of speech discrimination as reported among the same participants reflect the behavioral impact of auditory training changes in the central auditory system. Although these studies provided evidence that support the theory of Neural Plasticity in auditory training and adult rehabilitation, Brouns, El Refaie, and Pryce (2011) and Yu et al. (2017) acknowledge that they used small numbers of normal-hearing participants and hearing impaired participants. Therefore, they cannot be generalized for the entire hearing impaired population, and more research is needed with bigger sample sizes to allow generalization.

training as guided by the following research questions.

1. Is auditory training effective in improving speech perception and adult rehabilitation?

2. Are there specific forms of auditory training that are more effective?

3. What outcome measures tell the benefits of auditory training?

4. Does the duration of auditory training influence the final outcomes of auditory training and rehabilitation in adults?

5. What factors influence the outcomes of auditory training in adults?

By answering these questions, the thesis presents the available information and literature about auditory training and adult rehabilitation. For instance, the first question guides the thesis to evaluate the effectiveness of auditory training and rehabilitation in adults by examining exiting evidence. Therefore, evidence that supports effectiveness or lack of effectiveness is evaluated and conclusions made from that analysis. Similarly, the thesis uses the second research question to evaluate the types and forms of auditory training available and their effectiveness. In the same manner, the remaining research questions were also designed to guide this thesis in exploring other aspects of auditory training and adult rehabilitation. This way, the thesis obtained the information of interest as intended. When these questions are answered, the thesis recommends the best practices to attain the best auditory training and adult rehabilitation outcomes for patients with hearing loss.

MATERIAL AND METHODS

Study Design

This thesis followed a literature review study design and methodology to collect data. The study identified and evaluated different literature covering auditory training and adult rehabilitation. Relevant research articles and publications as well as reputable websites from government and international organizations were identified and used to retrieve suitable data. Because hearing problems and alternative solutions to treat and prevent them are numerous, this thesis had to narrow down the search to identify the most relevant materials only with regard to auditory training. Besides, the thesis focus was on adults, hence, further filters were needed to eliminate materials that were addressing other populations than the one specified. This way, the thesis identified the most suitable materials for analysis.

Search Strategy

First, reputable databases and organizations that could have relevant information with regard to auditory training were identified. PubMed, Frontiers in Aging Neuroscience, Sage, and Science Direct databases were selected as the potential sources of research materials and content. Additionally, the World Health Organization and the Centers for Disease Control and Prevention were identified as potential sources of essential information related to auditory training. These databases and organizations were chosen because they hold information relevant to auditory training and adult rehabilitation and they were sufficient to enable this thesis attain its objectives. To locate the suitable literature and publications, unique search terms and terminologies were developed. Combinations of key words such as "auditory training", "effectiveness", "theory", "neural plasticity", "types of auditory training", "benefits of auditory training", "adult rehabilitation", "outcomes", among others were used to narrow down the search and locate the most specific literature.

Inclusion and Exclusion Criteria

• Publishing time - the time of publication of an article did not prohibit inclusion. Many old articles were included if the information they had was still valid and applicable. Although the year of publication did not matter a lot, the oldest article included was published in 1997, and more focus was on the most recent articles and information.

• Topic- only articles and websites discussing hearing loss and auditory training were selected for inclusion.

• Authority - the websites included were from reputable sources such as WHO and governmental organizations, for example, the CDC. Only peer-reviewed articles from databases were included.

RESULTS

Effectiveness of Audiology Training in Improving Speech Perception and Adult Rehabilitation

The increasing use of auditory training and adult rehabilitation among individuals with hearing loss and the supporting theory of Neural Elasticity, many researchers have designed studies to evaluate the effectiveness of auditory training. Dubno (2013) reported about a study where two different computer guided auditory training programs were used to improve speech perception among the participants. The study was a randomized control trial, where the intervention group received training. Both intervention and control group participants were older adults suffering from mild to severe forms of hearing loss. Participants allocated to the intervention group were given either the word-based monaural program designed by the Indiana University, or the Speech Perception Assessment and Training System (SPATS) for a total of 30 hours. To determine the effectiveness of the training programs, Dubno (2013) reported that researchers measured the outcomes using objective measurements as opposed to subjective measurements. For example, the measured speech recognition that could be quantified objectively.

From this study, Dubno (2013) asserts that significant improvements were seen in the intervention group. Measurements performed demonstrated that participants receiving the training recognized different parts of speech such as sounds and phrases. Despite the improvements, the study revealed that significant training benefit differences were observed between individual participants. The possibility of generalizing was not constant and was significantly influenced by the tasks of speech perception, disrupting noise, strategies employed to listen, and scores obtained before training. In this study, there were no improvements recorded among the control group participants, which confirmed that auditory training was beneficial for elderly individuals with hearing loss.

Humes et al. (2019) also evaluated the impact of auditory training and adult rehabilitation, by investigating the procedure used in at home frequent-word auditory training. The subjects of this study were older adults suffering from impaired hearing, and who were wearing their own hearing aids. The study design was a randomized control trial with double-blinding and placebo control. It had three parallel branches; the intervention group that received auditory training referred to as at-home, another active control group receiving auditory training through audiobook in a similar set up as the at-home setting, and the third group comprising the passive control group whose members just wore hearing aids without any intervention (Humes et al., 2019).

Findings from Humes et al. (2019) supported the benefits and effectiveness of auditory training and adult rehabilitation. They explained that participants who were given the intervention referred to as at-home training was associated with better performance than the active and positive controls. Like in the previous studies, it was noted that generalization of the benefits to the wider population of hearing impaired individuals could not be applied even with accurate compliance to the program, because individual responses and benefits varied. Therefore, Humes et al. (2019) also demonstrated that auditory training is beneficial in speech perception. Evaluation conducted on follow-ups after the actual trial evaluation revealed that benefits attained through the training materials among the intervention group could last up to 8.5 months and beyond.

Many other RCTs demonstrate the effectiveness of auditory training among adults in improving speech perception and communication skills. Ferguson & Henshaw (2015b) revealed through a double-blinded RCT that auditory training produced improvements in the measured self-reported hearing, speech competition scores, as well as major cognitive tasks which required executive functions. From the observations of the study, it was suggested that cognitive benefits resulting from auditory training played a far more important role than sensory skills towards enhanced speech perception. Consequently, Ferguson and Henshaw (2015b) recommended that audiologists and other researchers should focus more on the sensitivity of outcome measures to determine the actual functionality benefits of auditory training and rehabilitation. The same study evaluated the effects of auditory training on the working memory and established that it lacked far-transfer for the untrained outcomes, thus, benefits could not be applied in generalization to the real-world listening capacities. Despite the lack of generalization, Ferguson and Henshaw (2015 b) noted that combined auditory and cognitive training approaches offer general real-world benefits of better listening abilities among adults suffering from hearing loss.

Similarly, Casserly, Krizmanich, and Drews (2019) tested the benefits and effectiveness of auditory training among 60 adults who received acoustic perception using a cochlear implant. The participants were first assessed for vocoded speech in a quiet environment and a noisy environment before the training. The auditory training was conducted after the pre-training assessments, then post-training assessments conducted. The assessments included a high-variability recognition of sentences in addition to recognizing selected cued words. With each test, scores were recorded and analyzed for comparisons between the different groups and the training materials used in the groups. The materials included interviews (audiovisual and audio) and isolating sentences. With this study design, Casserly, Krizmanich, and Drews (2019) established that speech recognition in both quiet and noisy environments improved significantly in audio and audio-visual interview groups. These groups outperformed the control group in all aspects of the generalized tests. Furthermore, participants undertaking the audiovisual interviews continued their engagement for a longer period. Therefore, this study also demonstrated the effectiveness of auditory training and adult rehabilitation to increase speech perception. The different randomized control trials reported in this thesis provide evidence of effectiveness of auditory training among adults for rehabilitation. The evidence is strong because the study designs of the studies analyzed fostered collection of essential data supporting the theory of neural plasticity and clinical data showing actual improvement in speech perception among hearing aid users. Therefore, this thesis agreed with this information and assert that the evidence provided is adequate to prove effectiveness of auditory training in promoting speech perception and efficiency.

Forms of Auditory Training and their Effectiveness

Auditory training involves different practices, programs, and sets of instructions designed to increase participants' speech perception. These programs and practices can be combined in different manners to formulate specific auditory training interventions suitable for individual participant's needs. Therefore, the thesis explored different types of auditory training programs and assessed their effectiveness as reported in literature. The first form of auditory training identified was spaced learning, where auditory training is done in spaced intervals. When one training activity is undertaken, a considerable break is taken before the second training activity (Tye Murray, Spehar, Barcroft, & Sommers, 2017). The spacing effect in human memory asserts that the human brain understands items better when they are in spaced intervals as opposed to massed/close intervals.

Therefore, Tye-Murray et al. (2017) evaluated this phenomenon to understand whether it was applicable in auditory training. Accordingly, they designed their study to compare efficiency of auditory training conducted with spaced intervals against the one conducted in a massed interval schedule. In the study, Tye-Murray et al. recruited 47 adult cochlear implants users and provided each one of them with a total of 16-hour auditory training. Participants allocated in the massed group received their training for five consecutive days every week, while those in the spaced interval group received training twice a week. To assess the impact of training and evaluate any possible differences between the groups, participants undertook speech perception tests prior to the training, immediately after the training, and three months after the training.

The outcomes of Tye-Murray et al. (2017) showed that auditory training enhanced speech recognition among participants from both spaced and massed schedule training groups. Moreover, the test after three months also revealed that benefits of auditory training were retained among the participants of both groups. Between the different schedule groups, there were no significant differences on the efficacy and benefits of training, retention, and generalizability. Therefore, the presence of or the lack of spacing effect did not influence the effectiveness of auditory training. As a result, Tye-Murray et al. (2017) postulated that auditory training and speech perception are possibly influenced by different factors other than the ones that control processes learnt better through spaced intervals such as the vocabulary. Hence, audiologists and other healthcare providers have the freedom when recommending auditory training schedules for their patients.

Computer-based auditory trainings are increasingly becoming popular as technological advances continue. Unlike the verbal one-on-one auditory training, computerized training programs are more flexible and can be easily modified to suit the needs of a hearing loss patient (Ferguson & Henshaw, 2015b). Therefore, researchers and audiologists are designing computerized auditory training and adult rehabilitation programs. For example, Vitti, Blasca, Sigulem, & Pisa (2015) noted that a web-based auditory self-training system was designed and developed for use among the elderly and adults using cochlear implants and other hearing aids. The web-based auditory self training system was beneficial for hearing loss patients because it combined two modules to promote better speech perception. The first module was for information purposes and gave users guidelines on appropriate use of hearing aids. The other module contained the auditory training module that presents a set of auditory training exercises to enhance auditory abilities and speech perception. Vitti et al. (2015) recommended that the web based self-training system should be used for at least one month with 30-minute daily sessions 5 days a week. The system incorporated five different auditory skills training. These were discriminating different sounds, recognizing sounds, temporal sequencing and comprehending, closures, and strategies for cognitive and linguistic communication. Therefore, computerization and web-based innovations in auditory training for adult rehabilitation are making auditory training more affordable and accessible among people who need it.

Outcome Measures for the Benefits of Auditory Training

To determine whether auditory training has been effective, researchers conduct different tests prior to the training and after the training and compare scores. If scores after the training are better than the initial scores, researchers conclude that the auditory training conducted was effective. Among the important test measures employed to evaluate effectiveness of auditory training are the Word-in-Noise (WIN) test, scores on vernal training, cognitive measure scores such as the Consensus Cognitive Battery score, and clinical signs and symptoms of hearing loss (Thomas et al., 2018). Other tests that researchers use to gauge the effectiveness and outcomes of auditory training include gap-in-noise, speech recognition-in-noise, and hearing in noise detection measures, the ability to discriminate between frequencies, Spectral Rippled Noise, Spectro-Temporal Modulation, and Iterated Rippled Noise (Barlow, Purdy, Sharma, Giles, & Narne, 2016). Researchers may also conduct auditory attention assessments, working memory evaluations, verbal memory examination, and executive functioning evaluations (Tarasenko et al., 2016). To evaluate the effectiveness of auditory training, researchers obtain the scores of their chosen test measures prior to the intervention and repeat the measures after the intervention. If the repeat measures are significantly better than the initial measurements, then, auditory training is proven to be effective.

One of the most effective measures is the word-in-noise test (Thomas et al., 2018). In this test, participants are given seventy monosyllabic words that are categorized into two lists, each having 35 words. The words are recorded in a noisy background. The test can be adapted so that the speech loudness fluctuates. However, the multi-talker babble remains constant throughout (Canadian Agency for Drugs and Technologies in Health, 2015). Each ear is tested individually and the test is administered through the earphone. The results are measured in terms of dB signal to babble ratio.

Another effective test measure that shows the effectiveness of auditory training is the frequency discrimination through hearing in noise test (HIT). In this test, the Canadian Agency for Drugs and Technologies in Health (2015) explains that the participant listens to 8 speakers, where one speaker presents the sentences and the other seven act as background noise. The main speaker presenting the sentences speaks at a distance of 1 meter, directly in front of the listener. The test comprises 250 sentences divided into 25 lists of 10 sentences each. In this test, the signal-to-noise ratio is changed according to the participant's performance, by adjusting the signal/speech level while the noise remains constant. For every correct sentence identified, the following sentence is presented in a lower speech level. Therefore, if the auditory training is successful, the participant identifies sentences that are presented in a lower speech level amidst a noisy environment more correctly than before the training.

Spectro-temporal modulation (STM) test measures are also used to evaluate the effectiveness of auditory training (Lotfi, Moossavi, Afshari, Bakhshi & Sadjedi, 2020). In this test, three different temporal modulation rates are used for spectro modulation tests. Typically, the 4Hz, 12Hz, and 32Hz temporal modulation rates are employed in conjunction with two different modulation densities, that is 0.5 cycles per octave and 2.0 cycles per octave. Before the training, the STM detection capacity is measured for the participant. The intervention group receives auditory training and the STM detection performance measures test repeated. If the intervention group produces better STM test scores than the control group, or if the scores are better than they were prior to the training, auditory training is shown to be effective.

Impact of the Duration of Auditory Training on Outcomes

The duration of auditory training is an important factor in determining the overall outcomes. However, the duration of training is determined by the patient's needs. For example, patients who receive cochlear implants require auditory training for the first few months of getting the implants (Henry, Pedley, & Fu, 2015). Some of the significant factors that determine the appropriate duration of auditory training include the length of time a person has been living with limited hearing, whether a person has used a different hearing aid previously and is starting to use a new one, as well as if the person has opportunities to listen to and converse with people using the hearing aid (Henry, Pedley, & Fu, 2015). Therefore, when these factors are combined with patients' needs, the appropriate duration of trained is known. Nonetheless, all patients who receive cochlear implants require regular auditory training for at least a few months after the initial implant (Fu & Galvin, 2008). Moreover, research also indicates that even patients who

Objectives

The main and general objective of this thesis is to explore the available knowledge and understanding of auditory training and rehabilitation among adults by reviewing different literature and existing evidence. The thesis uses this knowledge to recommend best practices in adult auditory training and hearing loss rehabilitation for optimal outcomes. It attains this objective by elaborating on five aspects of auditory have been using cochlear implants for a long duration of time may also benefit from auditory training (Oba, Fu, & Galvin, 2011).

The nature of training in terms of the total duration and the total number of training sessions is important because it influences the outcomes. Some researchers suggest that the optimal auditory training condition that fosters learning is the one that involves active listening to different items during successive sessions offered in a short time period, although it is not yet very clear about the most effectives protocols for auditory training (Caissie, 2019). For instance, in certain studies, longer training durations lasting 3 to 4 consecutive weeks and conducted 1 hour per day for several days a week (Stacey et al, 2010) and up to 12 weeks (Humes, Burk, Strauser, & Kinney, 2009; Woods, & Yund, 2007) have been recorded. Despite the long duration of training reported in these studies, improvement changes were observed as soon as within the first and second weeks of training (Caissie, 2019).

Performance improvement kept on increasing in the weeks that followed with sustained trained (Caissie, 2019; Woods, & Yund, 2007).

Contrarily, other researchers have reported shorter regimes and protocols of auditory training that were equally effective. For example, training periods that lasted for a total of one week have been recorded. In such cases, a total of between four and six training sessions were concentrated within a single week (Hawkey, Amitay, & Moore, 2004; Tremblay, Kraus, McGee, Ponton & Otis, 2001). At the same time, studies that evaluate the neurophysiologic changes that occur with auditory training demonstrated that such changes occur after a small number of training sessions, and some instances, after a single session of training (Caissie, 2019). Therefore, benefits of auditory training can be realized after a relatively short duration of training. For instance, Olson (2015) noted that approximately, a cumulative of 15 hours of auditory training is adequate to produce desired outcomes. More importantly, individual variabilities in auditory learning occur between individuals, especially on perceptual tasks, where some people learn faster than others. Also, maintaining individual neurophysiological changes after training varies between people (Caissie, 2019). This way, trainers should develop individualized training regimes depending on patients' needs and their characteristics.

The outcomes of auditory training are not always the same for different people. Several internal and external factors influence the outcomes. For example, the internal characteristics of a person with hearing loss such as motivation to learn may influence the overall outcomes. Psychosocial risk factors are among the significant factors that affect auditory training and rehabilitation outcomes. In one study, researchers evaluated the psychosocial factors that influence speech perception in older adults after a cochlear implantation surgery (Francis, Yeagle, & Thompson, 2015). Some of the factors evaluated as independent variables history of depression, the length of time of hearing loss, education, among others. The study established that the more time spent on the cochlear implant, the lower the speech perception was observed. Poor health status, poor education status, and residing in an assisted-living facility were other factors that negatively affected the outcomes of auditory training and rehabilitation (Francis, Yeagle, & Thompson, 2015). Accordingly, outcomes of auditory training are significantly influenced by psychosocial and health factors.

Laplante-Lévesque, Hickson, and Worrall (2010) evaluated different categories of factors that affect auditory training and adult rehabilitation outcomes. In the study, they noted that the convenience of receiving the training and rehabilitation had a direct relationship with the outcome, that is, the more convenient it is to receive the training, the better the outcomes. Adherence to the training and rehabilitation program was also essential in determining the overall outcomes, because lower adherence was associated with lower improvements (Laplante-Lévesque, Hickson & Worrall, 2010). The financial costs were also important because patients who felt that the program was too costly could not adhere fully, thus, did not get all benefits of a full program. The extent of hearing loss also determined the final outcome of training and rehabilitation, with the people having severe forms of hearing loss having poorer outcomes than people with milder hearing loss. Accordingly, Laplante-Lévesque, Hickson and Worrall (2010) recommended that all adult patients receiving auditory training and rehabilitation should receive individualized and patient-centered training regimes to address specific needs.

The nature of the auditory training and rehabilitation among adult patients also influences the final outcomes. Hassan, Hegazi, and Al-Kassaby (2013) demonstrated that a more intensive auditory training and rehabilitation program produces better auditory abilities and speech perception outcomes when compared to less intensive programs. Similarly, Sweetow and Palmer (2005) elaborated that different forms of auditory training and adult rehabilitation produce different outcomes. For example, they note that some patients report better outcomes when they are trained in groups. On the other hand, group training has its limitations because of the inability to provide individualized training. This way, patients with unique needs are not attended optimally as they are in individual therapies. Therefore, Sweetow and Palmer (2005) assert that individual auditory training and adult rehabilitation is more beneficial for patients with unique needs. The downside of individualized training is that it is costlier than in a group training and some patients may not afford. Therefore, different internal and external factors as highlighted here influence the overall outcomes of auditory training and rehabilitation for adults with different forms of hearing loss.

Discussion

Actions to Archive the Objectives

The objective of this thesis was to evaluate the knowledge available in the area of auditory training and rehabilitation in adults with hearing loss. With that knowledge, the thesis aimed to generate recommendations for the best practices to produce optimal outcomes with auditory rehabilitation. training Accordingly, and the adult thesis explored five knowledge areas of auditory training and rehabilitation. The areas explored were: evaluating the effectiveness of auditory training, exploring different types of auditory training, examining different measures and tests that determine the effectiveness of auditory training, assessing the impact of the duration of auditory training, and exploring different factors that affect the outcomes of auditory training. After exploring these knowledge areas, this thesis recommends the following best practices with auditory training and rehabilitation for adults with hearing loss.

Feasibility Plan of Action

Adults using hearing aids due to hearing loss should be directed for auditory training and rehabilitation.

The findings have demonstrated that auditory training helps patients using hearing aids due to hearing loss achieve better speech perception. Different randomized control trials were evaluated for the evidence of effectiveness of auditory training and rehabilitation (Casserly, Krizmanich, & Drews, 2019; Dubno, 2013; Ferguson and Henshaw, 2015b; Humes et al. 2019). This evidence was strong because the randomized control trial study designs fostered collection and analysis of objective primary data. With better speech perception, patients who receive auditory training and rehabilitation have better quality of life because their communication skills improve. Accordingly, the thesis recommends that all patients who use hearing aids such as cochlear implants should receive auditory training to improve their speech perception and communication skills.

Auditory training programs should be flexible to suit patients' schedules. After assessing different forms of auditory training, the thesis established that the process of auditory training is highly flexible and easily adaptable for different individuals and their needs. For instance, Tye-Murray et al. (2017) showed that auditory training enhances speech recognition and perception among patients whether it is conducted in a spaced or a massed/close schedule. They demonstrated that as long as the recommended number of training sessions is attained, the outcomes of training are satisfactory, regardless of how close or far apart the sessions are conducted. As a result, audiologists have the freedom to schedule training according to patients' availability, without interfering with the outcomes.

Audiologists should use the most suitable outcome measures and tests to determine the benefits of auditory training for individual patients. The thesis has established that there are many measures that gauge the effectiveness of auditory training. The test measures are usually conducted before the training, and then repeated after the training. When the scores are significantly different, with test scores after the training sessions being better, it is determined that auditory training is effective. Some of the test measures noted include the word in noise test, Spectro Temporal Modulation tests, hearing in noise tests, clinical signs and symptoms among other measures (Barlow, 2016; Thomas et al., 2018). Therefore, audiologists should select the most suitable test measures to evaluate pre and post auditory training scores, to determine the effectiveness of auditory training and rehabilitation.

The duration of auditory training and rehabilitation should correspond to the needs and preferences of the patient. As demonstrated in the thesis, benefits of auditory training are seen as early as the first week of training (Caissie, 2019). Nonetheless, durations of up to 12 weeks of auditory training have also been recorded with their benefits as well. Therefore, this thesis recommends that audiologists should evaluate individual patient's needs and characteristics to determine whether the patient is enrolled in a training program that runs for a long duration or a short duration, depending on the expected responses and outcomes.

This thesis has established that there are several factors that influence the outcomes of auditory training. Also, auditory training and rehabilitation should always consider factors that influence the final outcomes and incorporate them in the training regime, to come up with individualized plans and optimal outcomes. Some of the most notable factors among them include psychosocial factors such as depression, general health levels, education levels, and the duration and severity of hearing loss (Francis, Yeagle, & Thompson, 2015). Adherence to the training and the training cost were also important determinants of the overall outcomes of auditory training. With this understanding, audiologists should always consider these factors and how they apply to each patient, so that they can establish specialized auditory training and rehabilitation programs for individual patients to optimize outcomes.

Benefits to Archive

With the recommendations given above implemented, certain benefits will be attained. First, patients using hearing aids will improve their speech recognition and perception, hence, they will enhance their communication skills. As a result, they will overcome the negative impacts of hearing loss, such as the inability to recognize speech, inability to communicate, and lack of language acquisition as noted by Ohlenforst and Cols (2017). Second, hearing-loss among the elderly patients causes psychosocial negative impacts such as loneliness, isolation, dependence, and frustration, which lower their quality of life. With the identified recommendations, elderly patients receiving auditory training and rehabilitation will increasingly become better communicators and avoid the loneliness that comes with inability to communicate. As a result, their quality of life will improve (Ciorba, Bianchini, Pelucchi, & Pastore, 2012; Nordvik et al., 2018).

Most importantly, the recommendations given in this dissertation will ensure more people get auditory training to enhance their speech capacity. The first recommendation is that all people who use hearing aids after hearing loss should be guided to undertake auditory training and rehabilitation. As noted by Olson (2015) and Sweetow and Palmer (2005), hearing aids without auditory training restore the audibility for many hearing loss patients, but the actual problem of communication is not corrected. As a result, the patients continue struggling in their speech and communication. If this recommendation is implemented, more hearing loss patients will be receiving auditory training and enjoy the benefits of better speech perception and communication. With optimized auditory training and learning, more adults are able to return to the functional level of listening and interacting with other people through speech. Therefore, they can resume normal jobs and overcome the adverse economic impacts of hearing loss, especially the economic loss associated with lost productivity.

Conclusion

The main aim of this thesis was to explore the topic of auditory training and rehabilitation among adults with hearing loss. Therefore, it explored five different areas within this topic.

First, it assessed the available evidence on the effectiveness of auditory training and rehabilitation on enhancing speech perception among adults with hearing loss. The available literature demonstrated that auditory training has positive impacts in speech perception. People who receive auditory training perceive and recognize speech better, thus, communicate more efficiently. This evidence was obtained from the analysis of different randomized controlled trials. Second, the thesis analyzed different types of auditory training and compared their effectiveness. It established that whether the training sessions are conducted close to each other or are spread out over a long duration of time, the outcomes are equivalent if the number of sessions is similar. Therefore, patients can choose the nature and course of their training, without interfering with the expected outcomes.

Third, the thesis also evaluated the different types of tests and measures for determining the success of auditory training. Tests such as word-in-noise, Spectro-Temporal Modulation tests, hearing in noise, and assessing clinical signs and symptoms were identified as important when evaluating the effectiveness of auditory training. From these tests, audiologists should choose the most suitable for the patient and them, to enhance the evaluation process. Fourth, the thesis also evaluated the impact of short versus long durations of auditory training, and noted that effects are seen as soon as the first week of training, while some are seen as late as 12 weeks (Caissie, 2019). Therefore, individuals learn at different paces and audiologists should be ready to individualize training, Finally, the thesis examined factors that may influence outcomes of auditory training and rehabilitation. Internal and external factors such as motivation, psychosocial influences, financial costs, and adherence to the training program influence the outcomes. As a result, audiologists and other healthcare workers attending hearing-loss patients in auditory training should consider these factors and assess how they affect the patient to create individualized auditory training programs. When all of these factors are considered, auditory training and rehabilitation will be more successful because patients will be receiving training programs that are suited to their needs.

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