# REHBAILITATION FOR ADULTS: HEARING LOSS AND TINNITUS

Capstone Project

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By

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ABSTRACT

Hearing loss and tinnitus are two of the most prevalent chronic conditions in the United States. Studies on the prevalence of hearing loss and tinnitus reveal that, with a growing older population, the number of individuals needing rehabilitation for hearing loss and tinnitus will greatly increase (Cruickahnks, Wiley, Tweed, Klein, Klein, Mares-Perlman, & Nondahl, 1998; Nondahl, Cruickshanks, Wiley, Klein, Klein, & Tweed, 2002). Hearing loss rehabilitation can include many different strategies, including hearing aids, communication strategies, and auditory training. Research has suggested that all of the above mentioned strategies for hearing loss rehabilitation work for patients in improving quality of life (QOL) and communication. Tinnitus rehabilitation also has several methods that aim at managing tinnitus for a patient. These strategies, which include the tinnitus retraining therapy (TRT) and the Neuromonics tinnitus program, have been shown to succeed in decreasing a patient's perception of the tinnitus. All of the above mentioned methods, when used for the rehabilitation of hearing loss and tinnitus, have been shown to positively affect a patient by means of improving QOL, communication, and satisfaction with the rehabilitation services offered.

DEDICATION

For all those who supported me and believed in me.

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# FIELDS OF STUDY

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| TRT | Tinnitus Retraining Therapy |
| QOL | Quality of Life |
| LACE | Listening And Communication Enhancement |
| HHIE-S | Hearing Handicap Inventory for Elderly – Screening Version |
| EQ-5D | EuroQol 5 Dimenions |
| TRQ | Tinnitus Reaction Questionnaire |
| MML | Minimum Masking Level |
| LDL | Loudness Discomfort Level |
| SADL | Satisfaction with Amplification in Daily Living |

# CHAPTER 1

## INTRODUCTION:
## HEARING LOSS AND TINNITUS

As individuals age it is considered normal for bodily systems and organs to age as well. There are many obvious signs of aging such as a change in hair color, the wrinkling or decreased elasticity of skin, and the use of glasses. However, some of the most common chronic conditions in older adults, hearing loss and tinnitus, are invisible conditions because there are no outward visible signs. Hearing loss can be defined as a decrease in one's ability to hear sounds and may affect one or both ears. Hearing loss has been found to be the third most common chronic condition in older adults (Healthy People 2010, 2004). Hearing loss includes not only sensorineural hearing loss, by far the most common type of hearing loss, but other chronic ear issues, such as cerumen impaction, that are common among older adults. Tinnitus is defined as the perception of sound when no external signal is present. Tinnitus has been said to affect 50 million Americans of all ages and it has been found that anywhere from 8% to 32% of older adults have tinnitus (Nondahl, Cruickshanks, Wiley, Klein, Klein, & Tweed, 2002). The severity of tinnitus can range from barely noticeable to debilitating. It has been shown

that tinnitus increases in prevalence when a hearing loss is present, resulting in a large number of individuals with both a hearing loss and tinnitus (Nondahl et al., 2002).

In the mid 1990's, as many as 46% of adults over the age of 47 had some degree of hearing loss, increasing in prevalence with increasing age (Cruickshanks, Wiley, Tweed, Klein, Klein, Mares-Perlman, & Nondahl, 1998). Many studies on aging and hearing loss have projected an increasing prevalence of hearing loss due to the increasing number of older adults, specifically due to the aging baby boom generation (Sorri, Junio-Ervasti, Uimonen, & Huttunen, 2001; Vuorialho, Karinen, & Sorri, 2006). In turn, because tinnitus is highly associated with hearing loss, tinnitus may also increase as baby boomers age. Western countries are expected to have approximately a 10% population growth, from 15% to 25%, of individuals over the age of 65 within the next 20 years (Sorri et al., 2001). With the baby boom generation aging, the next 20 years will require a substantial increase in the audiologic care of older adults. The impact of treating and managing hearing loss and tinnitus will affect factors such as communication and psychological well-being.

Because audition is vital for oral communication, and communication is vital to staying connected with the world, hearing loss becomes a major obstacle when someone is trying to communicate. In the majority of adults with sensorineural hearing loss, the first sign that may be noticed is the inability to understand speech, especially in the presence of competing noise. It has been found that as adults' age, performance on speech recognition tasks become significantly worse and cannot be attributed to an increase in hearing thresholds alone (Souza, Boike, Witherell, & Tremblay, 2007). This suggests that communication for older adults is not simply based upon hearing

thresholds, but may also be based upon age-related changes within the auditory system. The impact of tinnitus on communication is not a factor that is widely studied by hearing scientists possibly due to the fact that tinnitus is considered an associated factor of hearing loss (Henry, Dennis, & Schechter, 2005; Henry, Jastreboff, Jastreboff, Schechter, & Fausti, 2002b). Because an individual with hearing loss may also have tinnitus, it can be difficult to determine if speech understanding difficulty is due to increased hearing thresholds or the perception of the tinnitus 'masking' speech, with the latter typically not considered.

Hearing impairment and tinnitus not only impact an older adult's ability to communicate and comprehend speech, but also include associated psychological impacts on socialization, cognition, and quality of life (QOL) (i.e., one's level of satisfaction with their life physically, socially, and emotionally) (Pichora-Fuller & Singh, 2006; Arlinger, 2003). For example, older adults with hearing loss can feel socially isolated due to the inability to hear speech. This in turn may cause feelings of exclusion from family or friends, and can lead to social isolation. Arlinger (2003) suggests that individuals who do not correct their hearing loss may suffer from depression or reductions in cognitive functioning. It has been found that profound hearing losses in older adults have a negative impact on daily living and is associated with decreased mental and physical functioning (Dalton, Cruickshanks, Klein, Klein, Wiley, & Nondahl, 2003). Dalton and colleagues (2003) discovered that even walking around the house or moving from a chair to a bed was more difficult when an individual had decreased hearing; although hearing loss does not actually reduce physical functioning, severe to profound hearing loss appears to negatively impact an individual's perception of these tasks. Tinnitus is also

highly associated with psychological factors such as anxiety and depression. Although there are not many studies that suggest tinnitus has a greater negative psychological effect on a patient than hearing loss, trends reveal that hearing loss is associated with QOL measures such as the ability to communicate while tinnitus is associated with psychological issues such as concentration and depression (Reynolds, Gardner, & Lee, 2004; Nondahl, Cruickshanls, Dalton, Klein, Klein, Schubert, Tweed, & Wiley, 2007).

As stated previously, hearing loss and tinnitus are chronic conditions that affect a great deal of adults and older adults and are two of the most common chronic conditions in this population (Chisolm, Johnson, Danhauer, Portz, Abrams, Lesner, McCarthy, & Newman, 2007). Because it has been shown that the prevalence of both hearing loss and tinnitus increases with increasing age, there is a great need for the treatment and rehabilitation of hearing loss and tinnitus (Cruickshanks et al, 1998; Sorri et al., 2001). . Audiologists will be expected to know the most beneficial forms of rehabilitation for hearing loss and tinnitus, with benefit typically seen by improved QOL and satisfaction with the treatments. However, with variety of services available to audiologists to treat these conditions, it can be difficult to know which are the most beneficial. The following paper will review not only the most common forms of treating and rehabilitating hearing loss and tinnitus, but also the treatments that have shown to be the most beneficial for the patient.

# CHAPTER 2

## REHABILITATION AND OUTCOMES FOR ADULTS WITH HEARING LOSS

Rehabilitation for hearing loss includes a variety of different services aimed at reducing the functional and social deficits due to the inability of hearing impaired individuals to effectively communicate (Boothroyd, 2007). The end result of rehabilitation should be an improvement in communication and should be measured via outcome measurements. Hearing loss rehabilitation can include the use of amplification devices, auditory training, and communication strategies provided via aural rehabilitation. Ideally, hearing loss rehabilitation would include all of the above mentioned components to achieve maximal benefit (Boothroyd, 2007). However, due to issues such as time constraints, cost, and even the lack of appropriate knowledge, the combined services are not used regularly.

While some audiologists may use one or two of the methods for the rehabilitation of older adults with hearing impairment, the most common service provided is the fitting of hearing aids. Although the use of amplification is by far the most common, there are instances when aural rehabilitation and auditory training are used in conjunction with hearing aids. Research suggests that combining several rehabilitation methods, such as

amplification and aural rehabilitation, results in better outcomes than any one method alone (Boothroyd, 2005; Neuman, 2005).

*Amplification*

Hearing aids have been available for many years, with the first electronic hearing aid invented in the early 1900's. New digital technology, however, has grown from 5% of the hearing aid market in 1998 to 90% of the hearing aid market in 2005 (Kochkin, 2005). With enhanced digital technology, including technologically advanced features such as noise reduction features and feedback prevention features, older adults have the ability to improve communication in a way that is relatively easy and effective.

Hearing aid technology creates a more effective avenue of communication for hearing impaired adults due to improved features such as directional microphones and noise reduction technology. However, the physiologic changes occurring in the auditory cortex due to lack of stimulation are not always considered. Research has suggested that damage to the peripheral auditory system results in decreased stimuli sent to the auditory cortex over time, therefore creating auditory deprivation (Neuman, 2005; Kral & Eggermont, 2007). The end consequence of auditory deprivation is a physiologic change within the auditory cortex via the reorganization of sensory maps (Palmer, Nelson, & Lindley, 1998; Neuman, 2005; Tremblay, 2005). The functional significance of auditory deprivation is typically seen in speech understanding.

Research by Silman and colleagues (1984) investigated and compared speech understanding scores in aided and unaided ears of veterans fit with hearing aids binaurally versus monaurally. Performance on speech recognition tasks after 5 years for

the binaurally fit adults remained stable. For the adults fit monaurally, the aided ear had a 4% drop in speech recognition tasks while the unaided ear had a 39% drop in speech recognition. This suggests that not only does auditory deprivation indeed occur when the brain does not receive stimuli, but it also suggests that the brain has plasticity or the ability to change the physiologic nature of the brain (Neuman, 2005). Sensory maps that have been altered due to auditory deprivation and show a decrease in neural activity in areas of the brain can also, in turn, increase when given appropriate input. Based on the findings of Neuman (2002) and Silman and colleagues (1984), increased auditory input after amplification allows for a reorganization of sensory maps within the auditory centers of the brain. Because of this, brain plasticity is beneficial when amplification is provided to older adults.

Research has revealed that when an individual is fit with a hearing aid, there is a specific period of time known as the critical period in which the individual will become accustomed or acclimatized to the hearing aid (Neuman, 2002; Silman et al., 1984). During acclimatization an increase in performance on many listening and sound detection tasks with the hearing aids is noted (Neuman, 2002; Silman et al., 1984). The critical period for acclimatization for an individual with a hearing aid is within the first 4-8 weeks, after which there is a plateau of performance. Therefore, the majority of outcome measurement research has been conducted within this time frame (Neuman, 2005; Tremblay, 2005). While many studies on hearing aid outcomes rely on data gathered within the first few weeks, one follow-up study by researchers from the Department of Veterans Affairs attempted to establish long term benefit and satisfaction with hearing aids 6 years after the initial fit (Takahashi, Martinez, Beamer, Bridges, Noffsinger,

Sugiura, Bratt, & Williams, 2007). Measurements included questionnaires on hearing aid use, benefit, satisfaction, and overall outcome or feelings due to the hearing aids. Results obtained were compared to the results from the initial hearing aid fitting 6 years previously. It was found that older adults who acquire hearing aids typically use them consistently, with approximately 50% of the participants wearing the hearing aids daily. It was also indicated that the main reason participants no longer used one or both of their hearing aids was due to damage, perception of little benefit, or inconvenience (Takahashi et al, 2007).

Takahashi and colleagues (2007) also found that the participants received benefit, satisfaction, and positive outcomes when using the hearing aids. When comparing perceived benefit from the initial hearing aid fitting 6 years prior to the present study 6 years after the hearing aid fitting, it was found that the hearing aids continued to show perceived benefit. However, it was also found that participants felt listening environments had become more difficult than when they were first fit with the hearing aids. For example, many of the participants felt that listening in a noisy restaurant had become more difficult the longer the hearing aids were used. This result may be explained by the acclimatization period: the participants had increasing performance with the hearing aids during the first 4-8 weeks and then a plateau effect occurring after the first 4-8 weeks. While patients do not actually decrease in performance with the hearing aids on listening tasks after the acclimatization period, they may experience the feeling of decreased performance due to habituating to hearing aids.

The amount of satisfaction found in the Takahashi (2007) study was measured via the Satisfaction with Amplification in Daily Life (SADL). The SADL is a questionnaire

that measures satisfaction with amplification in 4 dimensions: Positive effect, service and cost, negative features, and personal image (Cox & Alexander, 1999). The study revealed that satisfaction remained stable from the initial hearing aid fit to 6 years post fit and that participants were still highly satisfied, with a mean score of hearing aid satisfaction of 3.7 on a 5 point scale and a mean score of global satisfaction of 5.5 on a 5 point scale. The results of the hearing aid satisfaction questionnaire revealed that participants were most satisfied with their hearing aids when attempting to listen in quiet environments and least satisfied when attempting to listen in noisy environments, such as understanding speech in noise. The study also indicated that individuals who no longer wore their hearing aids reported reduced satisfaction because it was perceived that speech understanding in difficult listening environments was more difficult with the hearing aids than without the hearing aids. Global satisfaction indicated overall satisfaction and feelings due to the hearing aids, though less satisfaction was noted for difficult listening situations. Finally, despite concerns with difficult environments, participants felt the overall outcome when using the hearing aids was positive.

Several factors influence the perceived benefit from hearing aid use, such as degree of hearing loss, age of onset, and family support (Stark & Hickson, 2004). The majority of research on hearing aid benefit focuses on the hearing impaired only. One study, however, examined not only the benefit of a hearing aid fitting for the adult with hearing loss but also the benefit for the family or significant other (SO) (Stark & Hickson, 2004). Stark and Hickson (2004) suggested that hearing loss results in a lack of effective communication for everyone involved in the process, including the listener (hearing impaired adult) and the speaker (family member or SO). The purpose of the

research was to illustrate the positive effect of hearing aids not only for adults with hearing loss, but for the family member/SO as well via improvements in the communication process and QOL scores. To accurately compare an improvement in scores for the adult with hearing loss and the SO, modified versions of questionnaires were used for the SO. For the adult with hearing loss, the HHIE-S was used to measure self perceived benefit. For the family member/SO, a communication questionnaire (QDS-m) was modified in order for appropriate comparison with the HHIE-S. Both individuals also received the SF-36 to obtain information on health and QOL issues.

According to Stark and Hickson (2004), there were overall positive affects for the adults with hearing loss and their SO. There were significant reductions in the feelings of being handicapped by the hearing loss for both parties, resulting in increased feelings of benefit from the hearing aids. It was also found that the QOL measures for both parties were not significantly different from pre to post fitting. Surprisingly, for the adults with hearing loss, a subscale of the QOL measure actually decreased. This suggests feelings of reduced general health after the fitting of the hearing aids. The researchers attempted to explain the reasons for the perceived reduction in general health as the participants feeling old and fragile because of wearing hearing aids or becoming more aware of the severity of their hearing loss. However, conflicting evidence has found that utilizing amplification has resulted in improvements in areas such as overall QOL measurements, general health, satisfaction with daily living, satisfaction and feelings of benefit with amplification, and hearing handicap (Joore et al., 2003; Takahashi et al., 2007; Vuorialho et al., 2006).

The feelings of getting old and fragile for participants in the above mentioned study by Stark and Hickson (2004) could contribute to the decrease in the perception of general health. However, one caveat of the results is that of the 93 individuals in the study, only 13 wore the hearing aids consistently for 8 or more hours per day. As discussed previously, the acclimatization process to amplification may take weeks or months and is reliant upon the patient wearing the hearing aids consistently for the majority of the day (Palmer et al, 1998; Neuman, 2005; Tremblay, 2005). Because many of the adults with hearing loss within Stark and Hickson's (2004) study did not wear the hearing aids consistently, it is not surprising that there was no significant change in the perception of health status. However, it should be noted that the individuals did have an improved perception of benefit when wearing the hearing aids, resulting in a decrease in their hearing handicap. Further research may see changes in QOL measurements if more aural rehabilitative services are provided, such as counseling, communication strategies, and/or auditory training. Counseling patients on the benefits of wearing the hearing aids continuously, as well as the potential lack of benefit for inconsistent use, may result in more positive changes in QOL.

Hearing loss is known to cause difficulty in communication. However, hearing loss also has a less obvious impact on society. In general, the majority of people do not consider the societal issues associated when its members have a hearing impairment. One study examined the changes in QOL measurements for patients with hearing loss as well as the societal change when QOL is improved for patients with hearing loss (Joore, Brunenberg, Chenault, & Anteunis, 2003). The researchers assumed that an improvement in satisfaction and QOL measurements after receiving hearing aids would increase the

productivity of patients with hearing loss and cause a decrease in medical services used by the patients. The study included 80 patients with a moderate degree of hearing loss, with 31% of the patients being employed. The QOL measurement included the EQ-5D, the societal functioning measurement included in the SF36, and the productivity measurement used was a modified version of the Health and Labor Questionnaire. The medical services measurement was taken via questions asked during an interview with the patient.

The outcome of the study revealed a slight improvement in the QOL measure. Satisfaction ratings, which revealed feelings of disability and handicap because of the hearing loss, were significantly improved. Societal functioning measures were also significantly improved, suggesting the benefit of amplification for people with hearing loss is not only incurred by the person with hearing loss, but the society in which they live. And although the QOL measurement revealed improvements that were slight at best, there was a perceived benefit from the hearing aids for the individual. The other aspect of the current study was to determine if any changes would occur in productivity and medical services for the participants. The results revealed a slight improvement in productivity post hearing aid fitting; however, the significance of these findings may be difficult to establish based upon the extremely small sample size, with only 10 of the 80 participants being employed. It was also found that there was no significant difference in the use of medical services for the participants after receiving the hearing aids. No significant difference in the use of medical services, however, may be explained by the bundling of services provided to patients in health care. For example, a patient that visits an Ear Nose and Throat specialist for hearing may also be seen for sinus or throat

conditions, resulting in a skewed perception of the number of times a patient is seen for specific medical issues. Although the evidence supporting the benefit of amplification on productivity and medical services was lacking, Joore and colleagues (2003) did find supporting evidence for the fitting of amplification, with improvements seen in satisfaction, QOL, and societal functioning.

While several of the previous studies revealed that hearing aids do improve factors such as QOL and satisfaction, Vuorialho and colleagues (2006) wanted to compare benefits across several dimensions. Vuorialho and colleagues (2006) examined the change in perception of hearing disability and QOL for patients fit with amplification along the following dimensions: audiologic changes measured with speech intelligibility, disease specific changes measured with the HHIE-S, and QOL changes measured with the EQ-5D. The EQ-5D is a measurement that utilizes 5 factors, including mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. All of the mentioned measures were used to confirm any change to the patients perception of the hearing aids from pre to post fitting. Patients were interviewed before and 6 months after being fit with amplification, during which time the HHIE-S and EQ-5D were given and audiometric data was collected. The results revealed an improvement in the HHIE-S scores from pre to post fitting that was statistically significant. Although no statistically significant change was found in the QOL measure, when the patients were separated by gender, women perceived benefit for mobility and men perceived benefit for pain/discomfort and self-care. It was also found that speech intelligibility scores were improved from pre to post fitting (Vuorialho, Karinen, & Sorri, 2006). Future research

may attempt to resolve the differences in gender, such as answering why women did not show improved measures of quality of life and men did show improvements.

The research presented by Vuorialho and colleagues (2006) adds support for improved satisfaction and the benefit of amplification. The results indicated an improvement in speech intelligibility from pre to post testing with an 11 dB improvement in Speech Recognition Thresholds (SRT). An improvement in hearing handicap was also found. These improvements reveal the importance of using questionnaires such as the EQ-5D and the HHIE-S in that these measures collect data on the patient's perception of how the hearing aids work in real life situations. Audiologic measures such as speech intelligibility, while objective, do not always predict the functional results of hearing aids for an individual as well as questionnaires.

The majority of research on QOL is focused on audiologic measures to determine if hearing aids improve sensory perception and questionnaires to determine a patient's perception of improvement or benefit. Several of the previously mentioned studies revealed that benefit, satisfaction, and improvements in QOL from hearing aids are multi-dimensional and can be influenced by many aspects (Vuorialho et al., 2006; Humes, Garner, Wilson, & Barlow, 2001).

A further examination of dimensions that may impact results of QOL measures was conducted by Humes and his colleagues (2001). The study attempted to not only support the overall benefit of hearing aids for QOL measurements, but to establish and support more specific dimensions that effect QOL such listening environment and consistency of use. To establish the dimensions of HA benefit several questionnaires, including the HHIE-S, measured hearing aid benefit and QOL. The patients were tested

audiologically and given questionnaires before receiving hearing aids and one month after receiving hearing aids. Audiologic results revealed an improvement in speech understanding when using the hearing aids when in the presence of background or competing noise compared to speech understanding when not using the hearing aids. Similar to the study conducted by Vuorialho and colleagues (2006), the improvement in speech understanding with hearing aids was expected. The questionnaires used in the study also suggested an improvement in hearing handicap, noted by a decrease in the HHIE-S. While these findings were highly expected and were used for supporting evidence of the benefit of hearing aids, it was also intended to establish and support other well known dimensions that impact hearing aid fittings (Humes et al, 2001). One dimension that was found to effect perception of hearing aid benefit was the presence of background noise: a common issue with hearing aid users. The patients in the study revealed that they were most satisfied and found the hearing aids to be highly efficient and beneficial when in ideal listening situations (i.e., quiet) and highly inefficient in difficult listening situations (i.e., background noise). The last dimension noted by the researchers was hearing aid use and consistency; patients that used the hearing aids consistently had more improvements in the QOL measures. While the current study revealed several dimensions of communication difficulty that have historically been common complaints among hearing aid users, the study supports the overall benefit of hearing aid use (Hume et al, 2001).

*Communication Strategies via Rehabilitation Training*

The typical description of aural rehabilitation usually comprises use of amplification and another type of rehabilitation, such as counseling or auditory training. Most commonly, amplification and counseling are provided together during the hearing aid fitting. However, there are instances in which counseling is provided to patients in a class or group setting. During these classes, the audiologist may provide more details about the hearing system and hearing aids. Also commonly provided are methods or strategies for improved communication known as communication strategies. Communication strategies are methods utilized by an individual with hearing loss that can improve the processes of communication for not only the hearing impaired individual, but for all members involved (Chisolm, Abrams, & McArdle, 2004; Hawkins, 2005). Communication strategies may be used without any other form of hearing loss rehabilitation; however the use of amplification and auditory training has been shown to enhance the communication process (Chisolm et al., 2004). There are four components of communication strategies that may be modified and improved: the speaker, the listener, the environment, and the message (Weinstein, 2000). The speaker is defined as the individual sending out the message while the listener is defined as the individual receiving the message. The environment is the area where the speaker and listener are located and the message is the information being sent and received.

All of the above mentioned aspects of communication may be modified to improve communication. The first component that may be modified is the speaker. The speaker is the individual talking with a hearing impaired person. The speaker should talk clearly to a hearing impaired person, without shouting or over enunciating words. It is

also beneficial for the speaker to remove any objects that may be distracting from the mouth, such a chewing gum, and to ensure that they are looking at the hearing impaired person while speaking. Another modification that can improve communication may be done via the listener, the person with hearing loss. It is the responsibility of the listener to inform the speaker when a message is not heard. This can be done by asking for repetition, rephrasing, or verification. While it may be embarrassing for hearing impaired persons to consistently ask for repetitions, rephrasing or asking verification questions can achieve the same result. The third component that can be modified is the environment. Changes that will enhance communication in any given environment can include increased lighting, decreased background noise, and minimal distractions. It may also be beneficial to leave a difficult listening situation, such as a park or crowded venue, in order to have a conversation. Finally, the last communication modification occurs with the message. The most beneficial way for a message to be communicated to individuals with hearing loss is with a message that has relevant context and includes vocabulary that is familiar. It is also beneficial to make messages simple rather than complex. For the most beneficial communication to occur, all four aspects should be presented under ideal circumstances.

The benefits of providing communication strategies via aural rehabilitation classes can be seen in research conducted by Chisolm and colleagues (2004). In this study, one hundred six veterans were provided with amplification, with the Communication Profile for the Hearing Impaired (CPHI) being used as the outcome measurement for success. The veterans were randomly assigned to either the control group, veterans receiving only amplification, or the test group, veterans receiving

amplification and a 4 week course on aural rehabilitation. The aural rehabilitation course provided information on the auditory system, communication strategies, improving communication via strategies, and telephone/assistive listening device (ALD) use. Post hearing aid fitting, the veterans received the CPHI at 6 months and 1 year to determine if any significant differences existed between the groups in terms of communication performance, strategies, and personal adjustment. It was also the intention of the researchers to determine if there were any significant differences in the above mentioned aspects when compared at 6 months versus 1 year.

Chisolm and colleagues (2004) found that all the veterans who participated in the study had the perception of improvement in communication performance, communication strategies, and personal adjustment. However, the veterans enrolled in the aural rehabilitation course showed greater improvements within the first 6 months than the veterans not enrolled in the course in areas of verbal and nonverbal communication and on the CPHI. It was also discovered that one year after the fitting, both groups of veterans revealed improvements in communication strategy use. These results could be explained by the veterans who received communication strategy training via the aural rehabilitation course utilized these methods as soon as they were learned, hence resulting in greater short term benefits, while the veterans who were not enrolled in the course had to learn the strategies on their own over the course of the year. As Chisolm and her colleagues suggest, the lack of difference in the CPHI by 1 year may be clinically significant, in that a patient's decision to return a hearing aid is generally made within the first 4 weeks. Based on this, it may behoove audiologists to provide training or courses on

communication strategies so that patients have the improvements in communication immediately.

*Auditory Training*

Auditory training is a form of hearing loss rehabilitation that incorporates increasingly difficult listening exercises in an attempt to induce auditory plasticity (Sweetow & Henderson-Sabes, 2008; Tremblay, 2005). Historically, auditory training was provided in conjunction with amplification, with approximately 30% of audiologists providing this service. However, it has been shown that in the 1990's, the percentage of audiologists providing auditory training had been reduced to approximately 16% (Sweetow & Henderson-Sabes, 2008). The decrease in auditory training could be a result of improved hearing aid technology, including digital technology and advanced features, the amount of time it takes audiologists to provide auditory training, or the lack of adequate experience in providing auditory training. Whatever the reasoning, auditory training has decreased significantly in the last 20 years, resulting in amplification being the most common form of hearing loss rehabilitation.

The benefit of amplification for older adults with hearing loss has been greatly discussed and has been shown in a vast amount of research (Silverman et al., 2006; Silman et al., 1984; Joore et al., 2003; Humes et al., 2001; Vuorialho et al., 2006; Stark & Hickson, 2004; Takahashi et al., 2007). However, despite all the discussed benefits of amplification and the improvements in QOL measures, the market penetration of hearing aids is just slightly above 20%, meaning only one fifth of hearing impaired adults have hearing aids (Kochkin, 2000). It was also found that 16% of hearing aid users never wear

their hearing aids and 62% are dissatisfied with their hearing aids. With all the improvements in hearing aid technology, the amount of adults that are not receiving benefit due to not wearing their hearing aids or being dissatisfied with hearing aids is surprising.

Although several reasons may explain the low market penetration of hearing aids and the high dissatisfaction rate, one argument provided by Sweetow and Henderson-Sabes (2008) suggests that wearing hearing aids and maximizing a patient's ability to hear is not the only factor in satisfaction with hearing aids. Clarity and comprehension of speech is perhaps the most common complaint among older adults who utilize hearing aids. Hearing, however, is only a fraction of the step by step process of communication. Listening, a skill instead of a sense like hearing, may be a factor that has been previously overlooked. While hearing is a fundamental part of listening in that an individual cannot listen to speech if hearing is impaired, one does not have to listen even if hearing is available. Likewise, listening cannot occur without attention, resulting in the lack of comprehension and ineffective communication. Therefore, unless hearing, listening, and comprehension are maximally used to enhance communication, an adult hearing aid user may be dissatisfied (Sweetow & Henderson-Sabes, 2008; Sweetow & Palmer, 2005). Auditory training provides the skill to maximize listening by enhancing attention, utilizing acoustic information, and allowing for comprehension and beneficial communication (Sweetow & Henderson-Sabes, 2008; Sweetow & Palmer, 2005).

Research on auditory training has recently supported the utilization of a comprehensive method of rehabilitation that includes both the fitting of amplification and an auditory training program called Listening and Communication Enhancement LACE

(Sweetow & Henderson-Sabes, 2008). LACE comprises of a step by step program that enhances all the skills encompassed in communicating, including hearing, listening, comprehension, and communication. Hearing or perceiving an auditory signal is first established via amplification. Second, listening occurs when there is intent to pay attention to the auditory signal. Comprehension requires correct interpretation of the auditory signal and then results in effective communication. Based on the logical flow of the program, it can be seen that in order for communication to occur, hearing, listening, and comprehension must all be present. Sweetow and Henderson-Sabes (2008) utilized this process in a computer program to create interactive and adaptive tasks designed to enhance listening and comprehension. The tasks in the LACE program include exercises such as understanding speech in babble, time compressed speech, competing speakers, auditory memory, missing word, and interactive communication strategies. Because LACE is an interactive and adaptive program, correct responses lead to more difficult tasks and incorrect responses lead to easier tasks. All of the aforementioned aspects of LACE are combined to create a program that will enhance listening and communication.

Sweetow and Henderson-Sabes (2008) attempted to establish if the LACE program resulted in more improvements in speech understanding and communication for patients using it than for patients not using LACE. Outcomes measurements used to determine improvements in speech understanding in the presence of noise were the Quick Speech in Noise test (QSIN) and the Hearing in Noise Test (HINT). Also used for measurement purposes of overall benefit were the Hearing Handicap Inventory for the Elderly (HHIE), the Hearing Handicap Inventory for Adults (HHIA), and the Communication Scale for Older Adults (CSOA). Sixty-five hearing aids users were

placed into two groups, with one group starting LACE immediately after testing and was considered the test group and the other group starting LACE one month after testing and was considered the control group. Results revealed significant improvements for all measurements 4 weeks after using the program for the test group except on the HINT. Results also revealed no significant improvements for the control group. These outcomes suggest that the LACE program improves not only an individual's ability to hear in the presence of background noise, but also improves an individual's perception of benefit from the program and reduces feelings of being handicapped. With the recent development of the LACE program in only the past few years, more research still needs to be conducted to determine of the usefulness of the program.

# CHAPTER 3

## REHABILITATION AND OUTCOMES FOR TINNITUS

Rehabilitation for tinnitus has historically been difficult within the field of audiology. Because of the unknown origin of tinnitus, the multitude of potential theories and causes, and the wide range of beliefs and attitudes on clinical management, previous treatments have been minimal and have resulted in little success. The number of Americans with tinnitus is also unknown, though research has suggested anywhere from 8% to 32% American's currently have tinnitus (Nondahl et al., 2002; Henry et al., 2005). However, because the majority of tinnitus patients do not typically seek medical attention, it can be assumed that the prevalence is much higher than previously thought. While the more mild forms of tinnitus can go unnoticed by individuals, the more severe forms of tinnitus can be debilitating and may be accompanied by depression, migraines, insomnia, or many other health issues (Nondahl et al., 2002; Nondahl et al., 2007). The individuals with more severe tinnitus are typically those who seek treatment.

Tinnitus has been described numerous ways, from a high pitched ringing in the ear to a buzzing, roaring, whistling, whooshing, or cricket-like sound. While the description of the sound is variable, tinnitus is the subjective perception of a sound in the ear when no external signal is present (Henry et al., 2005; Holgers, Zoger, & Svedlund,

2005). As described above, the origin of tinnitus is not entirely certain. As well, factors or systems associated with tinnitus, or visa versa, are not certain. Some researchers suggest that there are associated factors with tinnitus, or causes of tinnitus, such as noise exposure or hearing loss while others suggest tinnitus is a symptom of other ailments such as hearing loss or Ménière's Disease (Henry et al., 2005). While tinnitus may be defined in either manner, as a system or a disease in itself, the management of tinnitus typically involves a combination of counseling and music therapy. The three main forms of tinnitus treatment include masking, tinnitus retraining therapy (TRT), and the Neuromonics tinnitus treatment program.

The use of the above mentioned treatments has been shown to reduce the perception of tinnitus for some patients, but the choice of treatment used can vary upon the philosophy and skill of the audiologist (Henry et al., 2002b; Hatanaka, Ariizumi, & Kitamura, 2008; Henry, Schechter, Nagler, & Fausti, 2002a). The philosophy of tinnitus management and treatment depends not only upon the treatment, but also the belief of the origin of tinnitus. One of the most common theories of the origin of tinnitus is based on a neurophysiologic model first presented by Jastreboff (1990). The neurophysiologic model is based on the physiologic and psychological reaction to sound (Henry et al., 2002b). As suggested by Jastreboff, the central nervous system identifies and processes environmental sounds based on the neural signal that is received. While some neural signals are essentially ignored, also known as habituation, other signals can activate the limbic system. Because the limbic system is responsible for emotion, an emotional response can occur with the signal and can result in behavioral responses. The emotional response may then be conditioned, resulting in the same behavioral response over and

over again with the repeated signal. If an individual's tinnitus causes a negative emotional response, any time there is the perception of tinnitus, the same negative emotional response may be triggered. This turns into a cyclical response pattern where the individual with tinnitus has a negative emotional response that continues without cessation.

If Jastreboff's theory is true, the most beneficial treatment or management for tinnitus would be one in which the cyclical response pattern is broken. Therefore, one of current treatment methods for tinnitus is based upon Jastreboff's theory and contends that tinnitus treatment must focus on 'retraining' the behavioral response coming from the limbic system and autonomic nervous system via counseling. This kind of treatment is known as Tinnitus Retraining Therapy or TRT (Jastreboff, 1990; Henry et al., 2002b). While TRT is a very common treatment of tinnitus, several other treatments for tinnitus have become available in recent years, including tinnitus maskers and the Neuromonics treatment program. There have also been developments in psychological rehabilitation for tinnitus, such as pain management and cognitive behavioral therapy.

*TRT – Tinnitus Retraining Therapy*

Tinnitus retraining therapy, based upon the neurophysiologic model, was first conceptualized and utilized by Jastreboff, who suggested that severe tinnitus was controlled by the limbic system and the autonomic nervous system. The purpose of TRT is to break the cyclical nature of the tinnitus, or the connection between the emotional and behavioral response elicited by the tinnitus (Henry et al., 2002a, Henry et al., 2002b). The purpose of breaking this cycle is so that the brain can habituate to the sound as it would

any other novel stimuli. The method Jastreboff uses for TRT involves two stages. The first stage attempts to remove the negative association with the tinnitus via counseling by an audiologist. The counseling and information provided to the patient during this stage is very structured and is intended to reduce any concerns or fears the patient may have associated with the tinnitus. The second stage of the therapy attempts to remove the tinnitus from consciousness via sound therapy, allowing the brain to habituate to the sound. The second stage can only be incorporated into the therapy if the first stage is accomplished. The use of sound therapy is also contingent upon the category that a patient is in. The category describes the severity of the tinnitus and any other issues associated with the tinnitus, such as difficulty sleeping, decreased loudness discomfort levels (LDL), or hyperacusis. Categories range from 0 to 4: Category 0 refers patients who are minimally bothered by the tinnitus; Category 1 refers to patients whose tinnitus had impacted at least one life activity such as sleep or work; Category 2 refers to patients who have hearing loss and tinnitus; Category 3 refers to patients with tinnitus and hyperacusis; Category 4 refers to patients with high intensity tinnitus that may be exacerbated via noise exposure (Henry et al., 2002b). The use of hearing aids, sound generators, or counseling alone is determined upon the category in which a patient is in. Based upon a success rate noted anywhere from 60 to 85 percent, TRT has been regarded as a highly promising and useful treatment for tinnitus (Henry et al., 2002b; Hatanaka, et al., 2008).

Controlled studies on TRT have not been conducted to date; however TRT efficacy has been determined with retrospective studies (Henry et. al, 2002a). At the Sixth International Tinnitus Seminar in 1999, six separate groups reported on the benefits

and efficacy of TRT. Jastreboff was one of the groups showing the benefits of TRT. Jastreboff examined data from 223 of patients from his clinic who had received TRT, including sound therapy via sound generators or hearing aids. The patients were enrolled in therapy for a minimum of 6 months and 81 percent of the patients showed a 20% improvement in two of the three outcome measurements: 1) the perception of their tinnitus as measured by the performance of daily activities affected by the tinnitus, 2) percentage of tinnitus awareness, and 3) annoyance due to the tinnitus (as cited in Henry et al., 2002a, p. 576). With the high percentage of success in this study with TRT, Jasreboff suggests that the use of directive counseling and sound generators can result in positive outcomes for patients with tinnitus.

Another clinical group that revealed positive outcomes with TRT was a study conducted by McKinney and colleagues (1999). This study, also retrospective, used 182 patients that had received TRT. However, unlike Jastreboff's data, McKinney used a 40 percent improvement to denote success in two or more aspects, including annoyance due to the tinnitus, impact on QOL, percentage of tinnitus awareness, and tinnitus loudness. Of the 182 patients, 54 received counseling only, 72 received counseling plus ear level sound generators or maskers, and 56 received counseling plus hearing aids. The greatest improvement was noted for the patients who received both counseling and sound generators, as seen by a 75 percent improvement rate. The remaining patients, those who received counseling only and those who received counseling and hearing aids, the percentage of improvement was 72 and 60, respectively. This study revealed that TRT resulted in an improvement of tinnitus via reduction in intensity and awareness for 60 to 75 percent of patients. However, it also suggests that counseling is the majority of

therapy for many tinnitus patients; this can be seen by the small difference between patients receiving counseling only and those receiving counseling and sound therapy.

*Neuromonics*

The Neuromonics tinnitus treatment program is the most recent development for the management and treatment of tinnitus. Neuromonics utilizes 4 separate music programs plus a customized dynamic acoustic neural stimulus designed to decrease the perception of an individual's tinnitus in order to make the tinnitus more manageable. The music and stimulus is provided to the patient via the Oasis device, which is similar to a music device like that of an MP3 player or iPod. The acoustic stimulus is a broadband frequency signal that is spectrally modified and customized for each patient (Hanley & Davis, 2008). The signal is based upon the patient's hearing loss and aspects of the tinnitus, such as pitch match and masking level. The concept of Jastreboff's neurophysiologic model applies to the Neuromonics treatment, where the purpose of the stimulus is to target the emotional reaction a patient has to the tinnitus (Hanley, Davis, Paki, Quinn, & Bellekom, 2008). However, differing from Jastreboff, Neuromonics incorporates systematic desensitization, resulting in a reduced emotional reaction to the tinnitus (Davis, Paki, & Hanley, 2007; Hanley & Davis, 2008). The treatment process includes a 6 month rehabilitation program with two distinct phases and structured sessions with counseling provided by a trained audiologist. During the first stage of the treatment, the treatment device provides the customized dynamic acoustic neural stimulus that masks the majority of the patient's tinnitus, allowing the patient some relief from the tinnitus. The second stage of the treatment provides intermittent coverage of the patient's

tinnitus, with high coverage of the tinnitus during the peaks of the music and low coverage of the tinnitus during the troughs of the customized music. The purpose of the device is to provide relief to the patient, therefore allowing a sense of control over the tinnitus and reducing the significance and neural enhancement of the tinnitus (Davis et al., 2007).

While Neuromonics has been a recent addition to the few tinnitus treatments available, with the first availability of the treatment was to patients in Australia in 2004, clinical studies have shown positive outcomes (Hanley et al., 2008). Hanley and his colleagues (2008) conducted a cohort study involving 470 patients in 7 clinics, with the purpose of determining the effectiveness of the Neuromonics treatment in the 'real world' for different categories or cohorts of patients. Outcome measurements were based upon the tinnitus reaction questionnaire (TRQ), minimum masking levels (MML), LDL, and subjective awareness of the tinnitus via the following question: "Over the past week, what percentage of the time while awake were you aware of your tinnitus". The researchers assigned the patients into 3 cohorts based upon their relative suitability for the treatment. Tier 1 patients were regarded as the most suitable for the treatment and had tinnitus only; Tier 2 patients had one or more associated disturbances, such as psychological disturbance, low TRQ score, or a moderate to severe hearing loss; Tier 3 patients had one or more associated disturbances, including reactive tinnitus, multi-tonal tinnitus, pulsatile tinnitus, Ménière's Disease, current ongoing noise exposure, or a moderate to severe hearing loss (Hanley et al., 2008). All patients were seen by audiologists who provided the standard protocol of care, including structured visits, phase changes to the treatment device, and counseling.

The researchers found that patients in Tier 1 who were highly suitable for the Neuromonics treatment had a 92% decrease in tinnitus disturbance, where success was defined as a 40% decrease in the TRQ (Hanley et al., 2008). Among the patients in Tier 2 and Tier 3, there was a decrease of 60% and 39%, respectively. The success rate for the patients in Tier 1 when compared to the success rate for the patients in Tier 2 or 3 was statistically significant. It was also noted that there were statistically significant improvements in all 3 Tiers for MML's, LDL's, and subjective awareness. Based on the results of the current study, it can be seen that patients with tinnitus and no other severe co-morbidities had a high level of success. For patients with very complex tinnitus and other potential co-morbidities, high levels of success were less likely. However, even when patients did not show a 40% reduction in the TRQ, other measurements that may contribute to more beneficial QOL were improved. Further research on the amount of time spent with the program, such as increasing the time from 6 months to 10 months, may result in greater success for more complex patients.

Another research study on the Neuromonics tinnitus treatment attempted to discover the clinical efficacy of the second phase of the treatment (Davis et al., 2007). The current program for Neuromonics suggests the use of the first phase is for relief from the tinnitus while the second phase is meant for desensitization and habituation of the tinnitus (Hanley et al., 2008; Davis et al., 2008; Davis et al., 2007). However, Davis and colleagues (2007) wanted to determine if the two phase program resulted in greater improvements than a single phase program. The study included 42 patients who were referred from ENTs and other health professionals and were included based on audiometric and clinical criteria: Better than 50 dB hearing loss in the better hearing ear,

clinically significant TRQ scores of 17 or greater, and no clinically significant comorbidites such as depression or psychosis. The 42 participants were randomly assigned into two groups: one group receiving a one stage program that allowed for intermittent tinnitus perception for the entire 6 months and the other group receiving a two stage program that allowed for full tinnitus coverage for two months and then intermittent tinnitus coverage for the remaining 4 months. Outcome measurements used included the TRQ, LDL's and MML's measured at 2, 4, 6, and 12 month intervals after the treatment ended.

The result of the current study revealed statistically significant improvements in TRQ scores for both groups when comparing pre treatment scores to post treatment scores (Davis et al., 2007). It was also noted that 86% of all the participants reported a reduction in tinnitus awareness 6 months after treatment. When comparing the two groups, it was found that 75% of the participants receiving a one stage treatment had an improvement in TRQ scores while 89% of the participants receiving a two stage treatment had an improvement in TRQ scores. MML's and LDL's were also noted as having statistically significant improvements post treatment for both groups, however those participants in the two stage group had a greater improvement than those in the stage one group. These results revealed that, while the intermittent stimulus included in the Neuromonics tinnitus treatment provided benefit for the majority of patients with tinnitus, it was the use of both stages that provided the greatest benefit. This suggests that a period of relief for patients from tinnitus should be a strong component for any tinnitus treatment, whether it is obtained during the treatment program as Neuromonics suggests, or via some other sound therapy device.

# CHAPTER 4

## CONCLUSION AND CLOSING REMARKS

Hearing loss and tinnitus are conditions that will most likely adversely affect individuals in a variety of ways, from psychological issues such as depression, aggression, and isolation to economic issues such as workers compensation and cost of health care. It is a fact that the prevalence of hearing loss and tinnitus tends to increase as individuals age, and currently the United States has an increasingly older population (Nondahl et al., 2002; Cruickshanks et al., 1998). Due to sensorineural hearing loss and the occurrence of tinnitus encompassing the vast majority of patients, the number of patients needing rehabilitation for both hearing loss and tinnitus will only continue to grow. In order to appropriately treat this growing number of patients, it is important to know not only what treatment options are available, but what treatment options provide the high level of benefit.

The aforementioned research overwhelmingly shows that rehabilitation for both hearing loss and tinnitus is beneficial for the patient. Hearing aids have been shown to improve QOL and satisfaction for patients that use their hearing aids consistently (Takahashi et al, 2007; Joore et al., 2003). These results support the benefit of hearing loss rehabilitation via amplification. Hearing aids have also been noted to not only have

benefits for the patient utilizing the aids, but can also positively affect the patients family members or significant others (Stark & Hickson, 2004). This is turn can lead to more fulfilling and overall positive relationships for hearing impaired individuals and their families. It was also found that other forms of rehabilitation, such as communication strategies and auditory training, can also be beneficial for a patients' overall well being as well as improving communication.

Historically, treatment options for patients with tinnitus were very limited. More recent treatments such as TRT and Neuromonics have given audiologists several options for their tinnitus patients. However, even with more options, tinnitus still remains a population in audiology that many professionals do not choose to work with; the reasoning being varied from time consuming to differing attitudes on treatment options. In 1999 Jastreboff's research on TRT revealed 81% of patients had a significant improvement in either the perception of their tinnitus, the percentage of tinnitus awareness, or annoyance due to the tinnitus. As well, other research has suggested the importance of counseling for patients in order to demystify or break the emotional connection with the tinnitus (McKinney, Hazell, & Graham, 1999; Henry et al., 2002a; Henry et al., 2002b). Another tinnitus treatment option, Neuromonics, has also shown to have improved outcome measurements such as reduced perception of tinnitus and improved QOL measures in as many as 92% of patients (Davis et al., 2007; Hanley et al., 2008). With current research suggesting that both TRT and Neuromonics results in reduced perception of tinnitus for the majority of patients, either treatment would be beneficial for patients.

The research provided in this paper revealed that a number of treatment options are available to rehabilitate and manage patients with hearing loss and tinnitus. While audiologists overwhelmingly utilize amplification for the rehabilitation of hearing loss, there are other tools that may be used for patients that need more assistance than hearing aids alone can provide. It can also be said that the majority of audiologist choose to not work with tinnitus patients. However, with the treatments currently available and the shown benefit of the treatments, more audiologists may start to see tinnitus patients. In an ideal world, rehabilitation for hearing loss would include amplification in conjunction with auditory training and aural rehabilitation while the rehabilitation for tinnitus would include counseling and music therapy via TRT or Neuromonics. While these ideal rehabilitation methods for hearing loss and tinnitus are not always used in today's world, it may not be far in the future where they are the standard treatments used with all patients.

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