Spring 1-1-2021

Is Hearing Loss Over-diagnosed Due To Impaired Cognition In Elderly Patients?

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IS HEARING LOSS OVER-DIAGNOSED DUE TO IMPAIRED COGNITION IN ELDERLY PATIENTS?

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Bachelor of Science in Communication Sciences and Disorders

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December 2016

Submitted in partial fulfillment of requirements for the degree

MASTER OF ARTS IN SPEECH-LANGUAGE PATHOLOGY AND AUDIOLOGY

at the

CLEVELAND STATE UNIVERSITY

May 2021

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for

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DEDICATION

This thesis is dedicated to a prior patient of mine who was my source of inspiration for this study, along with my family members and friends who have given me strength when I thought of giving up and who continually provided their moral support.

To my professors, cohort, and mentors who provided me advice and direction to make this thesis possible.

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ABSTRACT

The prevalence of hearing loss due to old age is rapidly growing amongst the elderly population impacting over 450 million people worldwide making it the third most chronic disease (Löhler et al., 2019). While highly prevalent, hearing loss still remains one of the least studied factors, yet it has one of the greatest impacts on public health as 67% of adults age 70 and up have a hearing loss that impedes daily communication (Lin & Albert, 2014). Research has found a connection between hearing loss and cognitive deficits. People with hearing loss experience cognitive decline 30% to 40% faster than same-aged normal hearing adults (Lin et al., 2013). When hearing loss is properly diagnosed and treated, it can aid in the preservation of cognition and residual hearing and help to improve quality of life in the elderly population.

The purpose of this small-scale study was to examine the professional practices and attitudes of 10 Hearing Instrument Specialists and 13 audiologists as it relates to the assessment of hearing in the elderly population. This study also examined whether or not there was a difference in the manner in which hearing professionals allow for challenges in behavioral testing of elderly clients, and to determine whether or not additional audiological assessment is sought for geriatric patients. The findings revealed no statistical difference between audiologists and HIS as it relates to hearing assessment of elderly people. Both hearing professionals rely on behavioral audiometry and are not likely to recommend elderly adults for additional audiological testing, even when the

behavioral results are less than reliable. There are important clinical implications from these findings to gather more reliable data to improve hearing aid fittings so that elderly adults can improve their overall quality of life.

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CHAPTER I

INTRODUCTION

Personal Experience

I worked at a hearing aid clinic for about two years, first as patient care coordinator (secretary/office assistant) and later as a hearing instrument apprentice (meaning that I was training to become a hearing instrument specialist under a licensed hearing instrument specialist). I had a 92-year-old male patient that had been a long-time hearing aid user (meaning that he wore hearing aids for over 20 years) who would religiously come into the clinic with his wife every six months for an updated hearing exam and for adjustments on his hearing aids (HA's). One day this gentleman came into the clinic stating that his hearing aids were too loud and needed to be turned down. Initially the gain was turned down on the hearing aids and the man was sent on his way.

The following week the man returned complaining again that HA's were too loud. This time the man's hearing was re-tested and his audiogram was compared to one completed within the last six months and even the last year. Side by side audiometric comparisons showed no changes in hearing thresholds. For many weeks this man continued to come in the with same complaint, his hearing aids were too loud. To help fix the associated loudness this man was experiencing, the compression ratios were adjusted on the hearing aids numerous times and some background noise was played after the adjustments to see how the patient was able to understand conversational speech in the presence of background noise. While in the clinic, the man reported that he was able to hear well and did not feel as though his hearing aids were too loud.

Despite several adjustments, the man continued to return on a weekly basis with the same complaint of his hearing aids being too loud. In seeing that there were no changes in hearing thresholds via side-by-side audiometric comparisons and after several hearing aid adjustments, I began to wonder if a cognitive deficit may be present and that maybe behavioral response testing was no longer the best or most accurate testing measure for this patient. I also began to wonder why there was no standard for testing the hearing of elderly patients with known or unknown cognitive deficits since I know that cognitive deficits can lead to inaccurate hearing thresholds with behavioral response testing. I wondered why there was a standard for testing the hearing of babies and young children using objective measures (auditory brainstem response testing) since they would not be able to adequately perform behavioral response testing, but why the same wasn't done for adults who might be inappropriate for behavioral response testing. This prompted me to propose a research study to explore what audiologists and hearing instruments specialist do to obtain accurate thresholds on elderly people with known or suspected cognitive deficits since there is no standard protocol for this population of people who so desperately need professionals to accurately assess their hearing.

Age-related Hearing Loss and Cognitive Decline

Loss of hearing with age (presbycusis) is something that will affect almost every person in society (Lin & Albert, 2014). Age-related hearing loss (ARHL), also known as presbycusis, is a hearing loss, usually sensorineural, which occurs as the auditory system naturally ages. ARHL is a highly prevalent condition. It affects one in three adults between the ages of 65 and 74. It is estimated that between 30-35 percent of adults over 65 years of age and 40-50 percent of adults over 75 years of age have a hearing loss (National Institute on Deafness and Other Communication Disorders [NIDCD], 2018). According to NIDCD (2018), ARHL is one of the most significant shared conditions among aging adults.

Research has found a connection between hearing loss and cognitive deficits. Adults with hearing impairments between ages 75 and 84 are at greater risk of cognitive and memory deficits compared to same-age adults with normal hearing (Lin et al., 2015). Researchers have also concluded that the rate of cognitive decline had a direct association with hearing loss. Specifically, individuals with a hearing loss experience a cognitive decline 30%-40% more rapidly than individuals without a hearing loss. (Lin et al., 2013). Furthermore, Maharani et al. (2018) suggested that neurological changes that negatively affect cognition are a result of a prolonged increased effort to hear auditory stimuli. Additionally, hearing impairment affects the healthy aging process of physical, social, emotional, and cognitive well-being.

Pure Tone Audiometry

For over 70 years, pure tone audiometry has been the "gold standard" used to assess the hearing in geriatric patients (Lycke et al., 2018). In pure tone audiometry, hearing is assessed by an instrument called an audiometer. An audiometer can determine the threshold for air conduction which involves testing how sound travels through the outer, middle, and inner ear. This is done using ear inserts or TDH-39 (over the ear) headphones. Bone conduction is assessed by placing a bone conduction oscillator on the mastoid process of the temporal bone to test how ossicular vibrations are sent to the inner ear (Al-Qahtani et al., 2020). Sounds are complex in nature which means they are composed of more than one frequency. During a hearing evaluation, an audiometer plays a pure tone sound which is composed of a single frequency (Al-Qahtani et al., 2020). Any time the audiometer emits a sound that is audible to the listener, the listener must press a button or raise a hand to signify that they heard the tone.

Two terms that are essential and related to sound are frequency and intensity. Frequency is the number of waves or cycles per second and is measured in Hertz (Hz) (Al-Qahtani et al., 2020). The pitch of a sound is related to its frequency, the higher the frequency, the higher the pitch, and the lower the frequency, the lower the pitch (Al-Qahtani et al., 2020). The decibel is a unit of measurement used to determine the intensity or loudness of a sound (Al-Qahtani et al., 2020). A normal conversation falls around 60 dB while a quiet naturistic environment may be around 30 dB HL. A decibel measures the relative intensity of a sound (Al-Qahtani et al., 2020).

When using pure tone audiometry and testing air conduction thresholds (AC), 250, 500, 1000, 2000, 4000, and 8000 Hz are measured. In bone conduction, all frequencies except 8000 Hz are measured (Al-Qahtani et al., 2020). Properly identifying the degree and severity of the hearing loss is an important part of determining the type of intervention needed. Anything that falls above 25 dB HL is considered to be normal hearing. Mild hearing loss is between 26-40 dB HL, moderate hearing loss falls between 41-55 dB HL, moderately severe hearing loss is between 56-70 dB HL, severe hearing loss is between 71-90 dB HL, and profound hearing loss is anything greater than 91 dB

HL (Al-Qahtani et al., 2020). Although it has been the "gold standard", pure tone audiometry is subjective and is not always best suited for people with a psychomotor impairment (Beck et al., 2014).

Electrophysiological Testing

Electrophysiological testing provides objective data about hearing acuity. This means that it does not rely on behavioral responses from the patient. Auditory Brainstem Response (ABR) is one type of electrophysiological testing. Electrophysiological tests are objective, meaning that they do not require a behavioral response from the patient. What this means is that the audiologist can measure the patient's electrophysiological responses (hearing thresholds) without the patient's active participation in the testing procedure (i.e. while under anesthesia or sedated). ABR testing is commonly used to test the hearing of newborns, but can also be used for the difficult to test population such as people with a cognitive impairment. ABR has been around since the 1970s and has served a crucial role in screening the hearing in children below three months of age. It has also played an important part in diagnosing hearing, tumors on the acoustic nerve, and cerebellopontine angle (CPA) tumors (Young et al., 2021).

Auditory brainstem response (ABR) testing assesses synchronous neural fiber activity along the auditory pathway to obtain hearing thresholds (Young et al., 2021). Mechanical sound is converted into electrical signals in the cochlea which are then sent to the brain through cranial nerve VIII. This electrical information to the auditory cortex travels along an ascending pathway through different nuclei (cochlear nuclei, superior olivary complex, lateral lemniscus, inferior colliculi, and medial geniculate nuclei). The hair cells in the cochlea convert physical sound input into bioelectrical action potentials that are transmitted to the spiral ganglion which makes up the main part of cranial nerve VIII (Young et al., 2021). The cochlea is tonotopically organized, with high frequency sounds starting at the base of the cochlea to low frequency sounds at the apex of the cochlea. Auditory nerve fibers from the base of the cochlea all the way to the apex travel along with the central and peripheral parts of the auditory nerve (Young et al., 2021).

The cochlear nucleus is the first relay point of the brainstem on the auditory pathway. It is located at the posterior part and side of the brainstem with low-frequency fibers on the frontal region and high-frequency fibers on the posterior region (Young et al., 2021). Past the cochlear nucleus, a majority of neural fibers intersect across the midline into the contralateral superior olivary complex. The superior olivary nuclei neural fibers are relayed to the ipsilateral inferior colliculus by the lateral lemniscus tract (Young et al., 2021). The medial geniculate nucleus in the thalamus gets afferent feedback from the inferior colliculus and sends it to the auditory cortex which is tonotopically organized (meaning it is organized based on frequency) (Young et al., 2021).

In ABR testing, an electrode is place high on the forehead, two electrodes are placed on the right and left earlobes or the mastoid process of the temporal bone, and a ground electrode is placed posteriorly on the lower forehead (Young et al., 2021). When testing hearing in adults using ABR, an acoustic stimulus is delivered through insert hearing phones at 80-90dBnHL at a standard and high repetition rate. For patients that have hearing loss, the intensity of the sound can be adjusted to 60-65 dB SL. Hearing Level (HL) is based off of hearing thresholds for a standard population and Sensation Level (SL) is based on hearing thresholds for the tested ear. If a person were to have a

60-65 dB SL, it would mean that the stimulus was 60-65 dB above the threshold of the tested ear (Young et al., 2021). The stimulation intensity should be increased by 10 dB increments until reproducible waveforms are shown, allowing for the analysis of thresholds (Young et al., 2021). The waveforms are then evaluated for reproducibility, wave structure, and latency. Latencies for the right and left ear are compared to determine if an abnormal neural synchrony or retrocochlear pathology exists. There should be no greater than a 0.4-millisecond difference with the Wave V latency between ears (Young et al., 2021).

The stimulus is presented monaurally (one ear at a time) to compare the responses between ears and to help prevent crossover of the stimulus (Young et al., 2021). There is however still potential for the stimulus of one ear to cross over to the non-test ear through air or bone conduction and thus can lead to an action potential, so masking is used to prevent this (Young et al., 2021). The non-test ear is masked using continuous white noise that is presented 30-40 dB below the stimulus. Responses to electrical potentials are recorded for 10 milliseconds after the stimulus presentation and can be extended to 20 milliseconds for patients with pathologically prolonged waveform latencies (Young et al., 2021).

Auditory Brainstem Response testing also known as “human auditory evoked potentials” is sub-category of Electroencephalogram (EGG). An EEG detects electrical brainwave activity and then sends these responses to a computer which are then projected on a monitor (Medwetsky, 2016). An EEG can be performed without external stimuli present (e.g. when the pt. is asleep) and when this is the case, the EEG produces characteristic wave patterns, but when external stimuli is present, these wave patterns change (Medwetsky, 2016). ABR is similar in this fashion as it works by detecting electrical changes from the scalp after the presentation of a sound. Responses that are created by external stimuli (evoked responses) are created at all levels of the auditory nervous system including the auditory reception regions of the brain. ABR audiology measures the transmission of evoked neuroelectrical signals along the auditory nerve and brainstem pathways (Medwetsky, 2016).

The sound level below which a person is unable to detect sound is known as hearing threshold (Medwetsky, 2016). When it comes to performing hearing test via ABR, no patient response is required to detect a hearing threshold. Instead, neuroelectrical responses from the auditory nerve and brainstem are recorded and the lowest level of intensity that a reliable response can be recorded at is the threshold (Medwetsky, 2016). This differs from behavioral response testing as behavioral response testing requires the patient to be actively listening to various tones presented and then to either press button or raise a hand to indicate that they heard the sound no matter how soft it is. In behavioral response testing, the lowest level at which the patient can hear and respond to the tones presented 50 percent of the time is the behavioral threshold (Medwetsky, 2016).

Young children and people that are cognitively impaired can be fit with hearing aids solely based off results from ABR testing (Medwetsky, 2016). For example, electrophysiological testing is used on children 6 months and under and sometimes on children up to age 6 as there are limitations to the behavioral responses, especially if a psychomotor impairment exists (Beck et al., 2014). To fit the population mentioned above, frequency specific thresholds need to be obtained which can be done using toneburst ABR audiometry (Medwetsky, 2016). For example, electrophysiological testing is used on children 6 months and under and sometimes on children up to age 6 as there are limitations to the behavioral responses, especially if a psychomotor impairment exists (Beck et al., 2014).

Hearing Instrument Specialists and Audiologists

There are two groups of individuals who are generally sought when a person is seeking help for their hearing loss: Hearing Instrument Specialists (HIS) and audiologists. The level of education and scope of practice are the two major differences between the two types of hearing care professionals. Both HIS and audiologists are specially trained to provide high quality service to people who have hearing loss. HIS and audiologists work with people who are living with age-related hearing loss.

A hearing instrument specialist is a "state-licensed hearing care professional who has been trained to evaluate common types of hearing loss in adults, and to dispense hearing aids" (Clason, 2020). Every state has the responsibility of licensing hearing instrument specialists, and in some states, they are also known as hearing aid dispensers. While hearing instrument specialists are trained to provide hearing evaluations to fit hearing aids, audiologists are trained to perform full diagnostic evaluations of the auditory system from the outer ear to the brain. Audiologists often work closely with otolaryngologists (ear, nose and throat physicians) to diagnose and treat complex hearing problems.

The educational requirement for an audiologist in the United States is a Doctorate in Audiology (AuD). Audiologists must also obtain a license to practice in each state. Audiologists may also become certified by the American Speech-Language-Hearing

Association. The scope of practice for an audiologist includes working with infants, children, adults, and the elderly population, providing assessment and intervention to minimize obstacles a person may have communicating difficulties due to a loss of hearing or auditory perception.

Hearing instrument specialists' "educational requirements are less than audiologists' requirements and vary by state", (Clason, 2020, p. 1). Every state establishes their own set of requirements, but at a minimum, hearing instrument specialists (HIS) must have a high school diploma and complete a rigorous training program that usually takes two years to complete. The required program of study for hearing instrument specialists includes anatomy of the ear, acoustics, assessment hearing, hearing aid selection and fitting, hearing aid assistive technology, and counseling (Clason, 2020).

While there are differences in the level of education and scope of practice, both audiologists and HIS are dedicated professionals who play an important role in the diagnosis and treatment of hearing loss in the elderly.

The Impact of Hearing Loss on the Elderly

Despite the large prevalence of hearing impairment among the elderly, a relatively small proportion of those with hearing loss seek help for their hearing problems, and for those who are fit with hearing aids, there are still many people who do not use the device. Knudsen et al. (2010) stated that "between 1% and 40% of hearing aids dispensed are never or rarely used" (p. 127).

Kozlowski et al. (2017) cited Magni et.al (2005) by reporting that in a study of 3,000 hearing aid wearers, it was found that only 59% reported being satisfied with the performance of their prosthesis. There is an urgent need for professionals who work with elderly clients, to reduce the number of individuals who have hearing aids and do not use them, as well as to reach the large percentage of elderly individuals who have hearing loss, but who have not sought help for the problem. This is because of the significant impact that auditory sensory deprivation has on the life of an individual. Hearing loss not only affects an individual's ability to detect sound or to properly understand auditory information, but it also affects the manner in which people relate to their environment and their culture (Kozlowski et al., 2017). In addition, this sensory deprivation causes biological, psychological, and social consequences, and has been linked to significant cognitive decline in the elderly.

Research findings have associated hearing loss due to the natural process of aging (presbycusis) and cognitive decline. Adults with hearing impairments between ages 75 and 84 are at higher risk of cognitive and memory deficits compared to same-age adults with hearing within normal limits (Lin et al., 2015). The decline in cognition may also not only relate to sensory changes to sound, but to motor changes as well.

In a study done by Albers et al., (2015) evidence shows that people may display sensory and motor changes prior to showing cognitive symptoms of Alzheimer's disease. Specifically, elderly people tend to show a slowing of motor movements, especially in response to auditory stimuli. This may impact the manner in which an elderly person responds to pure tones when their hearing is being assessed. If the elderly person is directed to press a button when a sound is heard, the person who is also experiencing cognitive decline, may be slow to respond to the sound. When there is no response to sound, in audiometric testing, the standard protocol requires the clinician to increase the intensity of the tone until the client responds. What happens if the client heard the tone, but is experiencing cognitive decline, and the clinician increases the intensity of the tone, and finally the client raises their hand? The result may be that the clinician records the higher level as the "threshold," when the client actually heard the tone at a lower intensity, but due to psychomotor slowing, his response to the tone was delayed.

The research done by Albers et.al. (2015), highlights on the importance for hearing instrument specialists and audiologists to account for these psychomotor impairments when using behavioral response testing on the geriatric population. Hearing loss is one of the least studied factors, but is one with the greatest impact on public health as the prevalence of hearing loss doubles with age, every decade and because of this 67% of adults age 70 and up have a hearing loss that impacts their daily communication (Lin & Albert, 2014).

This thesis sought to determine if HIS and audiologists consider the possibility of cognitive decline and account for this when testing elderly patients, and to see if there was a significant difference between the two groups as it relates to behavioral testing with elderly clients. If hearing loss is not accurately diagnosed, the patient will be improperly fit with hearing devices (hearing aids) thus making them less likely to wear their hearing aids. When hearing aids are properly fitted, research has shown that they aid in slowing the decline in cognition as well as preventing social isolation and depression (Hidalgo et al, 2009). For this reason, is important to accurately diagnose hearing loss in the elderly population in order to prevent social isolation and depression as these factors contribute to cognitive function and impact the overall quality of life.

Purpose of the Study

The purpose of this study is to examine the professional practices and attitudes of HIS and audiologists as it relates to the assessment of hearing in the elderly population. This study also examined whether or not these hearing care professionals (AuD's and HIS') acknowledge an association between hearing loss and cognitive decline in the elderly, to determine if there is a difference in the manner in which these hearing professionals allow for challenges in behavioral testing of elderly clients, and to determine whether or not additional audiological assessment is sought for geriatric patients, such as electrophysiological testing when behavioral testing yields unreliable responses from elderly clients.

Significance of the Study

There are 450 million people worldwide impacted by presbycusis (Löhler et al., 2019). Hearing loss remains one of the least studied factors, yet it has one of the greatest impacts on public health as 67% of adults age 70 and up have a hearing loss that impedes daily communication. The prognosis for hearing loss in old age (presbycusis) is further progression of hearing loss. The best treatment of hearing loss in the elderly is properly fitted hearing aids. To be fit with hearing aids a person must undergo a hearing test in order to have hearing aids programmed to their loss. The role of testing hearing in patients with a potential cognitive deficit is poorly understood. This study will hopefully emphasize the significance of using all available tools to accurately assess hearing in order to provide appropriate hearing aid fittings for patients age 65 and older who may also have a co-existing cognitive deficit. Properly fitting hearing aids will improve hearing aid use among the elderly. Use of hearing aids have proven to be highly effective in slowing declining cognition. With improved access to sound and maintenance of cognitive ability, elderly people have a better chance to improve the overall quality of their lives.

Research Questions

This study was guided by the following research questions:

1. Do audiologists and hearing aid specialists acknowledge an association between hearing loss and cognitive decline in the elderly?

2. Is there a difference in the manner in which audiologist vs. hearing instrument specialists allow for challenges in behavioral testing of elderly clients?

3. Do audiologist and hearing instrument specialists refer elderly clients for electrophysiological testing when behavioral testing reveals unreliable responses from elderly clients?

CHAPTER II

REVIEW OF THE LITERATURE

Presbycusis (hearing loss due to old age) is becoming more prevalent due to the expanding, aging population. Presbycusis is one of the most common deficits, and according to the World Health Organization, it impacts 450 million people worldwide (Löhler et al., 2019). One in three people over the age of 65 will be impacted by hearing loss. Most people are unaware that they have a hearing loss due to its gradual progression. A study done in Germany found that 16.2% of adults have hearing loss and that about 6.5% of people use amplification (Löhler et al., 2019). Shahidipour, et al. (2013), stated that hearing is the third most chronic disease in the elderly population next to arthritis and hypertension (HTN) and that 40-45% of the population over the age 60 and older have some degree of hearing loss. Shahidipour et al. also stated by 2030 a predicted 44 million Americans will have some form of hearing loss (2013).

Hearing is a complex phenomenon that requires vibrations from the eardrum to set the ossicular chain into motion. The motion of the ossicular chain leads to a displacement of fluid in the cochlea in the inner ear that sets hair cells into motion (Salvi et al., 2017). The motion of these hair cells creates electrical impulses that travel down the auditory nerve and to our brain which our brain then interprets as a sound. Our cochlea is comprised of three times the amount of outer to inner hair cells. The inner hair cells are responsible for transmitting sounds to our brain as they synapse (meaning that an action potential is evoked) with 90-95% of type I auditory nerve fibers (Salvi et al., 2017). This means that our inner hair cells are responsible for transmitting a vast majority of the information that we hear to our brain (Salvi et al., 2017).

Behavioral Audiometry – Pure Tone Audiometry

Pure tone audiometry has been deemed the gold standard for detecting hearing thresholds and is used to determine hearing sensitivity or in other words is used to determine the softest sound that is audible to a patient. Pure tone audiometry is a form of behavioral testing and is the procedure that is most often used to assess hearing in elderly people. Behavioral testing relies upon the accuracy of the responses provided by the client. Pure tone audiometry is performed by placing over the ear headphones or ear inserts into a patient's ear, playing a series of beeps and having the patient either raise their hand, say "yes", or press a button whenever they hear the beep no matter how soft the sound is (ASHA, 2021). Hearing is tested at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz in a soundproof booth and the responses at each frequency or thresholds are recorded on an audiogram (ASHA, 2021). The audiogram is a chart that graphically displays an individual's hearing acuity. The audiogram has an X and a Y axis. The X axis represents frequency which is measured in Hertz (Hz) and the Y axis represents intensity which is measure in decibels (dB) (ASHA, 2021). People who have a hearing threshold of 20 dB HL or less are considered to have "normal hearing", anything that is greater than 20 dB HL is considered to be a specific degree of hearing loss (e.g. 21

dB HL and up), ranging from slight hearing loss to profound hearing loss (Salvi et al., 2017).

Salvi et al. explain how behavioral response testing (pure tone audiometry) fails to identify certain cochlear pathologies and auditory processing problems (2017). Salvi et al. then goes on to say that despite someone obtaining normal hearing thresholds (≤ 20 dB HL) based on pure tone audiometry results, an undetected hearing loss may still be present (2017). This means that a person could have significant inner hair cell or auditory nerve fiber degeneration that is going undetected and could be leading to their temporal processing deficits, distorted speech perception, difficulty hearing in background noise, and in some cases tinnitus (ringing in the ears) and hyperacusis (perceiving sounds to be louder than what they are), (Salvi et al., 2017). For this reason, it is crucial that we find accurate ways to assess this hidden or undetected hearing loss in the aging population to determine the effects of inner hair cell and auditory nerve damage on central and peripheral auditory processing (Salvi et al., 2017).

Electrophysiological Tests - Electrocochleography

One way that this hidden hearing loss can be detected is through Electrocochleography (ECochG). Electrocochleography can be used to determine the functional status of the structures within the cochlea and detect damage to inner hair cells (IHC) outer hair cells (OHC) , inner hair cell (IHC) type I auditory nerve fiber synapse, and spiral ganglion neurons (Salvi et al., 2017). Since sensorineural hearing loss (meaning hearing loss to the inner ear) is a complex phenomenon that involves several structures in the central auditory system and not just the cochlea, these other structures may be compensating for the cochlear damage. For this reason, a more accurate assessment should not only involve ECochG, but should also assess neurophysiological changes that occur in the central auditory pathway (Salvi et al., 2017).

Salvi et al. performed electrophysiological, neuroanatomic, behavioral, and neuropharmacological experiments on a chinchilla animal model by giving them an ototoxic anti-cancer agent carboplatin that led to damage of the inner hair cells and type I auditory nerve fibers that exclusively innervate the inner hair cells (2017). What they found was that chinchillas with a few large inner hair lesions had normal hearing thresholds in quiet until their inner hair cell loss went beyond 80% (Salvi et al., 2017). What this means is that only a few inner hair cells are needed to detect sounds in quiet, meaning that in quiet the auditory system can compensate for the inner hair cell loss, but not in the presence of background noise (Salvi et al., 2017). They also found that the way the brain handles this loss of cochlear input is by increasing the gain of weak signals in order to reach a comfortable level of loudness. While this gain can help a person with IHC loss in quiet situations, it may not adequately compensate for peripheral dysfunction in the presence of background noise or more complex acoustic environments (Salvi et al., 2017). They also suggest that these compensatory gain increases may lead to hyperacusis. Salvi et al.'s (2017) study demonstrates how ECochG can be used to detect damage to the inner hair cells and type I neurons that are missed using with behavioral response testing (pure tone audiometry).

ECochG is an objective measure of hearing that can be used to detect hidden hearing loss. Oher electrophysiological measures of hearing sensitivity include otoacoustic emissions (OAE) and auditory brainstem response (ABR) audiometry.

Electrophysiological Tests – Otoacoustic Emissions

Otoacoustic emissions (OAEs) are sounds that start at the cochlea in the inner ear and propagate in a somewhat "backwards" fashion through the middle ear space, the tympanic membrane and finally in the ear canal where they can be measured with a sensitive microphone. Martin and Clark (2019) stated that Kemp in 1979 first described these emissions when he discovered that normal cochleas are capable of producing sounds in the absence of external stimulation. These spontaneous otoacoustic emissions range from 1000 – 3000 Hz and are found to be between -10 and+10 dB SPL. The sounds are inaudible to the person in whom the otoacoustic emissions are measured.

Otoacoustic emissions can also occur immediately following acoustic stimulation. These emissions are called evoked otoacoustic emissions. The use of OAEs have clinical usefulness in the differential diagnosis of sensorineural hearing loss in populations that are difficult to test such as infants and individuals with an intellectual disability.

There are some drawbacks to using otoacoustic emissions alone to diagnose hearing loss. For example, it was discovered that otoacoustic emissions reflect the integrity of the outer hair cells. This means that a person with damage or loss of inner hair cells could "pass" a test with OAE and still have a hearing loss. The discovery of this fact emphasized the importance of using a battery of tests to verify the severity and type of hearing loss.

Electrophysiological Tests – Auditory Brainstem Response Testing

When sound waves reach the inner ear, they are transformed so that what is transmitted to the brain is a series of neuroelectrical events (Martin & Clark, 2019). Since hearing is a phenomenon that involves the brain, Martin and Clark (2019) explain that “it is only logical that whenever a sound is heard, there must be some change in the ongoing electrical activity of the brain” (p. 180). These changes in the ongoing electrical activity are called auditory-evoked potentials, and they can be recorded from the scalp using surface electrodes. Auditory evoked potentials can be subdivided on the basis of where and when they occur. The auditory evoked potentials that occur in the first 10 to 15 milliseconds after the introduction of a signal are said to originate in the VIIIth cranial nerve and the brain stem and are called auditory brainstem responses (ABRs). Each wave in the ABR is said to represent neuroelectrical activity at one or more sites along the auditory brainstem pathway. The ABR can be used to determine thresholds of hearing sensitivity and correlates very closely to reliable pure tone results. Due to its objective nature, “the ABR has developed into the most important test in the diagnostic site-of-lesion battery” (Martin and Clark, 2019). The ABR has high specificity and sensitivity in the accurate assessment of hearing sensitivity and in the detection of lesions that are located along the auditory pathway to the brain.

ABR has become the preferred method for the assessment of hearing sensitivity in the difficult-to-test, and is frequently used in newborn hearing screenings. ABR can also be used to verify questionable responses that are obtained with behavioral audiometry.

It should be noted that ECochG, OAE, and ABR testing can be completed by audiologists. Hearing instrument specialists are trained to use OAE and in some states can screen hearing with ABR.

Hearing Loss, Aging, and Cognitive Decline

In addition to loss of hearing, cognitive deficits are also prevalent among aging adults. A cognitive deficit is an impairment in the mental processes that support learning and retaining information. Domains such as attention, memory, and reasoning are affected. Research findings have found an association between hearing loss due to aging and cognitive decline. Adults with hearing impairments between ages 75 and 84 are at higher risk of cognitive and memory deficits compared to same-age adults whose hearing is within normal limits (Lin et al., 2015).

A systematic review from Loughrey et al. provided background information, including known history of hearing loss being associated with cognitive ability, cognitive impairment, and dementia (2018). The systematic review and statistical analysis contained 36 studies consisting of 20, 264 participants. Loughrey et al. stated that cross sectional studies found a small, statistically significant association between age related hearing loss and all ten cognitive areas of concern (global cognition, episodic memory, executive functions, processing speed, semantic memory, and visuospatial ability). In addition, Loughrey et al. stated that a statistically significant association between age related hearing loss and cognitive impairment was found, along with a significant association between age related hearing loss and dementia (2018). Overall, presbycusis (hearing loss due to aging) is a possible risk factor for cognitive decline, cognitive impairment, and dementia.

To understand how presbycusis can impact these cognitive areas (global cognition, episodic memory, executive functions, processing speed, semantic memory, and visuospatial ability), it is important to understand what neurological regions and functions are associated with them. Episodic memory is the ability to encode, store, and consciously recall previously learned events that have occurred recently (within minutes) or over a span of time (within years), (Cacciaglia et al., 2018). Episodic memory performance has been related to intact medial temporal lobe structures, by which the hippocampus controls learning and retrieval of information in conjunction with the entorhinal, perirhinal, and parahippocampal cortices. Executive functions involve the ability to implement task-directed behavior via strategic selection, monitor information, and plan the order of actions. Executive functioning relies on the prefrontal, other frontal regions, and parietal cortex of the brain. Both of these play an important role in our day-to-day life and show a prominent decline in neurological disorders (i.e. dementia, Alzheimer's disease) and aging (Cacciaglia et al., 2018). Semantic memory involves long-term storage of verbal information (Harvey, 2019). This verbal information is processed via the declarative memory system. Semantic memory allows for the information to be consciously recalled at a later date and helps to aid with new declarative memory tasks such as processing of dates, names, places, and facts (Harvey, 2019).

Processing speed refers to cognitive processing assessments that require a quick performance on tasks ranging from simple to complex (Harvey, 2019). Original processing speed tasks include coding of symbols and connecting numbers or letters in a sequence like the Trail Making Test. The main feature of processing speed tests is that the patient is instructed to perform the test as quick as possible. Another important feature of processing speed is that it is typically the biggest predictor of overall cognitive performance on cognitive tests (Harvey, 2019). Some populations that have difficulty with processing speed include people with Parkinson's disease and people with cortical and frontostriatal degenerative conditions (i.e. Alzheimer's, Pick's disease, cerebral palsy, fronto-temporal dementia) (Harvey, 2019). In addition, a reduction in processing speed is also experienced during the aging process.

Visual cognition has been assessed in the presence of hearing loss and when doing a side-by-side comparison of middle-aged adults (average age of 50) with hearing loss to those with normal hearing, changes were found on simple and passive shape detection tasks in the hearing loss group which correlated with worse speech-in noise understanding (Gillingham, et al., 2015). Overall, researchers of the study suggested that differences seen in visual evoked response in the hearing loss group correlated with a decrease in speech in noise detection (Gillingham, et al., 2015). As a result, they proposed that the differences in visual processing changes may result in decreased auditory processing by recruiting neurological regions away from that sensory domain in order to compensate for the hearing (i.e. allowing more focus on visual cues such as lip reading or facial movements) (Gillingham, et al., 2015). Together episodic memory, executive functions, processing speed, semantic memory, and visuospatial ability all make up global cognition.

Longitudinal studies assessing the elderly population who live throughout the community on their own as opposed to being taken care of in nursing homes have shown that hearing loss in this population is independently associated with a 30-40% acceleration rate of cognitive decline on both auditory and non-auditory tests with a significantly higher risk of incident all-cause dementia (Lin & Albert, 2014, p. 671). Research also shows that individuals with a mild, moderate, or severe hearing loss in comparison to those with normal hearing have a two, to three, or even five times as great of an incidence of all-cause dementia over a span of ten years. (Lin & Albert, 2014, p.

671). Brain scan images have shown independent correlations of hearing loss with reduced brain matter in the auditory cortex. (Lin & Albert, 2014). Additionally, a person with hearing loss has encoding difficulties (interpreting the sound and then performing a behavior or reaction as a result) due to damage of the hair cells in the cochlea and because of this, greater mental resources are needed to encode the sounds and in turn it takes away from the cognitive resources devoted to other things such as working memory (Lin & Albert, 2014). A recent brain scan has shown that people with hearing loss have faster rates of whole brain atrophy in addition to a decrease in brain volume in the right superior, middle, and inferior temporal gyri over an average span of 6.4 years of follow up. These temporal areas are important for spoken language processing, semantic memory, sensory integration, and are involved in the early stages of mild cognitive impairment or the early stages of Alzheimer's disease (Lin & Albert, 2014, p. 671).

Previous longitudinal studies have assessed the progression or change in hearing loss and its relation to neurological status over an average span of 11.9 to 20 years. A population-based prospective cohort (ARICC) longitudinal study of 15,792 men and women age 45-64 years old recruited from 1987 to 1989 from four different US state counties (Washington County, MD; Forsyth County, NC; Jackson, MS; and Minneapolis, MN), was done by Deal, et al., (2015). Deal, et al. administered neuropsychological tests representing different cognitive domains (memory, language, and processing speed/attention) from 1990-1992, 1996-1998, and in 2013, (2015).

Out of 253 participants, 73 (29%) had no hearing impairment (HI), 95 (37%) had a mild HI, and 85 (34%) had a moderate to severe HI (Deal, et al., 2015). Upon the third testing administration done in 2013, the average age of the participants was 76.9 (Deal, et, al., 2015). Deal et al. found that found that over a 20-year period, people with a moderate to severe hearing loss had a greater decline in memory, language, and processing speed (three cognitive domains) in comparison to people with normal hearing (2015). In addition, Deal et al. found that over the 20-year span, people with a moderate to severe HL who did not wear/use hearing aids (HA's) were found to have greater change in memory and global function than those who did wear HA's (2015). Estimated declines in the cognitive domains were also greater for non-hearing aid users (Deal, et al., 2015).

In a longitudinal study done by Albers et al., evidence shows that people may display sensory and motor changes prior to showing cognitive symptoms of Alzheimer's disease (2015). Albers et al. also touched on the importance of recognizing and catching the existence of non-cognitive functional changes, such as sensory or motor changes, as it may help to identify people 10 or 15 years before they are clinically diagnosed with Alzheimer's disease (2015). A prospective study utilizing data from the Baltimore Longitudinal Study of Aging has shown that peripheral hearing loss, measured using pure tone audiometry is independently associated with incident dementia. In this prospective study, a group of 639 adults without prevalent dementia or mild cognitive impairment at baseline was followed for an average of 11.9 years. Hearing loss at baseline was associated with the risk of incident all-cause dementia (Albers et al., 2015).

A study done by Hidalgo et al. (2008) states that the prognosis for hearing loss in old age (presbycusis) is further progression of hearing loss. Properly fitted hearing aids can slow the progression of presbycusis and aid in successful rehabilitation and also prevent social isolation and depression in this population (Hidalgo et al, 2008). For this reason, Hidalgo et al. did a study to determine the prevalence of hearing loss in people age 65 and up and also assessed the functional status of the people impacted by hearing loss. In Hidalgo et al.'s (2008) study, 1162 people were assessed: 506 (43.6%) subjects had hearing impairment (HI), and that number increased with age as 63% of subject over the age of 75 were found to have a HI. Hidalgo et al. found that functional status was also impacted by hearing loss and that 42% of participants age 75 or older had difficulty carrying out activities of daily living (ADLs) and that 8% of participants had extreme difficulty in carrying out ALDs. Hidalgo et al. also noted that behavioral response testing (pure tone audiometry) requires the patient to have a decent level of awareness and the ability to fully cooperate. For this reason, Hidalgo et al. argues that behavioral response testing cannot be performed on patients with severe cognitive impairment and this group of people was not included in the study (2008). Results from Hidalgo et al.'s study also found that only 4.5% of the elderly subjects studied own hearing aids and that although 89.3% could benefit from them, they don't own them which equates to over a third of the elderly population age 65 and up (Hidalgo et al., 2008).

Impact of Cognitive Decline on Quality of Life in the Elderly

Hearing loss may have devastating consequences for the social, functional, and psychological well-being of the person. Quality of life is a term that is used to describe a person's general well-being. Several studies have demonstrated that "presbycusis may have a negative effect on the quality of life and psychological well-being—social isolation, depression, anxiety and even cognitive decline" (Ciorba, 2012, p. 6).

Several authors have reported that hearing loss is an increasingly important public health problem that has been associated with a diminished quality of life because hearing loss interferes with the exchange of information and significantly impacts everyday life, especially for elderly people (Ciorba, 2012; Lin, 2015).

According to Ciorba (2012), the impact of presbycusis on the quality of life include: emotional reactions, such as loneliness, isolation, dependence, frustration, depression, anxiety, anger, embarrassment, frustration, and guilt; behavioral reactions, such as bluffing, withdrawing, blaming, and demanding; and cognitive reactions, such as confusion, difficulty focusing, distracting thoughts, and decreased self-esteem.

The National Council on the Aging (2014) reported that among people surveyed who had with hearing loss, only 39% perceived that they have an excellent global QoL level or very good physical health, compared to 68% of those without hearing loss. In addition, people with hearing loss are less satisfied with their "life as a whole" than people without hearing loss.

Presbycusis has been reported to be the cause stress that occurs due to the inability to effectively communicate. It is natural, then, for the person with the hearing loss to withdraw from participating in events that will require social participation. Hearing loss among the elderly has been reported to be a cause for loneliness, isolation, depression, and dissatisfaction with family life.

When the person with the hearing loss does not have the benefit of amplification, and do not have sufficient strategies to manage communication breakdowns, they are at risk for experiencing reduced self-esteem.

There has been hope for improving the quality of life among elderly people with hearing loss in the literature. Researchers have explored the benefits of hearing aid use among the elderly. It appears that hearing aid use is associated with improvement in the overall quality of life. Joore et al., (2002) found that new hearing aid users experienced less anxiety and depression after using hearing aids. Chisolm et al. (2007) reported that hearing aids improved adults' scores on a self-assessment scale by reducing the psychological, social, and emotional effects of hearing loss.

Behavioral vs. Objective Audiometric Testing and Cognitive Decline

In a systematic review done by Bott et al., they found that 41-43% of adults with dementia were unable to complete behavioral response testing (2019). For this reason, Bott et al., discuss the importance in finding an alternate means of testing for this specific group in order to address their specific hearing needs (2019). Previous audiograms can be used if available, along with otoacoustic emissions (OAE's), in addition to adjusting the hearing aids based on subjective feedback from the client (patient living with dementia), however this is suboptimal as the clinician has to estimate the patient's hearing threshold (Bott et al., 2019). For this reason, auditory-evoked potential (AEP) testing has been suggested as an alternate means for testing the hearing for patients with dementia and is also highly recommended by ASHA (Bott et al., 2019).

In a study done by Burkhalter et al., (2009) they looked at the effectiveness of behavioral response testing for nursing home residents from a sample size of 307 residents. In the article, Burkhalter et al., discussed how a third of people age 65 and up, living in nursing homes have some form of a visual or hearing impairment and that 46% of these residents have some form of dementia (2009). Out of a sample size of 307 residents, Burkhalter et al., found that 168 residents (54%) displayed dementia or dementia-like behaviors which led to inaccurate audiological results. Burkhalter et al., argues that the current guidelines for behavioral response testing for patients living in nursing homes does not sufficiently address the needs of the patient when a cognitive impairment exists (2009). Since the nursing home dwelling population is hard to test, Burkhalter et al., argues that there needs to be some sort of established protocol for audiologists when testing the hearing of these patients (2009). Out of the 307 residents tested, only 112 were able to complete pure tone testing and only 34 were able to complete pure tone and bone conduction testing (Burkhalter et al., 2009). Burkhalter et al., goes on to say how there was a recognized need to implement specialized testing procedures for pediatric patients with or without a cognitive or behavioral disorder because they are difficult to test and discussed how it is relevant to implement a similar or modified specialized protocol for this difficult to test geriatric population (2009).

In a study done by Lemke (2011), they discussed how the possibly of dementia and hearing increases with age and how a large majority of people with dementia have a co-occurring hearing loss. In nursing homes, 60-80% of the residents have some form of dementia, with Alzheimer's disease being the most common (occurring in 50-70% of cases). The prevalence of hearing loss is estimated to occur in 30-40% of people age 65-74 years of age and increases to 50-80% by age 75 and older (Lemke, 2011). Hearing loss has been known to escalate cognitive deficits and for this reason, hearing intervention has the ability to slow down the progression of cognitive decline (Lemke, 2011). Hearing and cognition are addressed by separate professions and one rarely refers patients to the other (Lemke, 2011). For this reason, hearing loss is not always found during a dementia screening, much like cognitive deficits are not always acknowledged or accounted for/found during a hearing test (Lemke, 2011). Unfortunately, people with dementia are often not considered as candidates for amplification as hearing tests are often not done due to anticipated difficulties during testing procedures (Lemke, 2011). If hearing impairments are not properly addressed, it can speed up the rate of cognitive decline and dementia in old age (Lemke, 2011). Lemke conducted interviews with both hearing instrument specialists and audiologists in the US and Germany that both test the hearing of patients and fit them with hearing aids. Each reported that pure-tone audiometry was the most commonly used procedure for testing hearing in patients. They also agreed that modifications may need to implemented when using pure-tone audiometry on patients with a cognitive impairment (Lemke, 2011). For this reason, Lemke argues that it is important to adapt specific clinical procedures for patients with cognitive impairments to help improve hearing health services and rehabilitation (Lemke, 2011).

Summary

The prevalence of hearing loss increases with age. Research has proven that there is a connection between hearing loss and cognitive decline in elderly people. Elderly people with untreated hearing loss are five times more likely to experience cognitive decline than those elderly people without hearing loss. Research has also shown that when hearing aids are used, there appears to be a slowing in the decline of cognition. Elderly people who do not wear their hearing aids are more likely to become isolated and to experience a further loss of hearing and cognition which in turn has a negative impact on their overall quality of life.

Elderly people seek the help of audiologists and HIS for their hearing loss. Both professionals heavily rely on behavioral audiology to determine the amount of hearing loss and use data from behavioral testing to select hearing aids for their clients. Research has shown that behavioral testing in the elderly may be negatively impacted by a slowing of psychomotor response time and processing speed. Electrophysiological testing such as ECochG, OAE, and ABR, offers objective ways to assess hearing sensitivity. These tests do not rely on the response of the patient who may have subnormal cognitive functioning. However, only audiologists can assess hearing via ECochG and ABR. Further, the use of electrophysiological audiometric techniques may not generally be recommended for use in elderly populations by audiologists or Hearing Instrument Specialists.

This study sought to determine if HIS and audiologists take the possibility of cognitive decline into account when testing elderly patients, and if there was a significant difference between the two groups as it relates to behavioral testing with elderly clients. The next chapter describes the methodology used to gather data to provide insight into this phenomenon.

CHAPTER III

METHODOLOGY

This study was approved by Cleveland State University's IRB. Chapter three describes the research design and methodology used to investigate the following research questions:

1. Do audiologists and hearing aid specialists acknowledge an association between hearing loss and cognitive decline in the elderly?
2. Is there a difference in the manner in which audiologist vs. hearing instrument specialists allow for challenges in behavioral testing of elderly clients?
3. Do audiologist and hearing instrument specialists refer elderly clients for electrophysiological testing when behavioral testing reveals unreliable responses from elderly clients?

Hearing loss and cognitive decline in the elderly are commonplace. Research has shown that elderly people with an untreated hearing loss are five times more likely to develop dementia. Research has also shown that although 16.2% of elderly people are eligible for hearing aids, only 6.5% actually wear them or own them. Of that 6.5 %, many hearing aid owners report dissatisfaction with their hearing aids, which results in lack of use of the instruments. The dissatisfaction of the hearing aids has been attributed to the overall appearance of the hearing aid and the quality of the sound, including a primary complaint that the hearing aid was too loud (Mizutari, 2013).

Adults are identified as candidates for hearing aids based upon behavioral testing that is completed by audiologists or hearing instrument specialists. These professionals primarily rely on behavioral testing to determine eligibility and programming for hearing aids. If an elderly person has some form of cognitive decline, they may respond inappropriately, which may cause inaccurate results and lead to inaccurate programing of the hearing instruments. These inaccurate measures of hearing thresholds can lead to over or under amplification resulting in further strain or progression of hearing loss, causing the user to wear their devices less. Our profession of communication sciences and disorders has a responsibility to ensure accurate testing of elderly adults. Only then, can we ensure that we are appropriately serving our elderly clients who are depending upon us to obtain accurate results

Survey Construction

Hearing instrument specialists and audiologists were selected for the study. A Qualtrics survey was sent out to 112 participants via email. Some email addresses were obtained from the Ohio Speech and Hearing Professionals Board, which is the licensing organization for audiologists and hearing instrument specialists in the state of Ohio. Other email addresses were obtained by Internet searchers of private practitioners in Ohio, Florida, New Jersey, and Wisconsin.

A 30- question survey was constructed to explore how Hearing Instrument Specialists approach behavioral testing of elderly clients versus Audiologists, and their professional perspectives related to elderly clients, cognitive decline, and audiometric testing. The survey was sent to 112 professionals via email. Of the 112 surveys sent, 13 surveys were returned from audiologists and 10 surveys were returned from hearing instrument specialists. The first part of the survey was designed to obtain demographic information. The second part of the survey asked questions about professional practices when testing elderly clients. Questions were answered on a seven-point Likert scale with the following designation:

1 = Strongly Agree

2= Agree

3= Somewhat Agree

4 = Neither Agree nor disagree

5= Somewhat disagree

6 = Disagree

7 = Strongly disagree

A sample of questions related to professional practice included

- For patients 65 and older, I wait 5 seconds before increasing the decibel level by 5
- For patients 65 and older, I wait more than 10 seconds before increasing the decibel level by 5

-Hypothetical situation: A patient who has not had their hearing tested in over a year comes in and requests that you increase the gain on their hearing aids. You increase the gain based on the old audiogram.

-Using pure tone audiometry is one of the best ways to obtain accurate threshold measures in patients 65 and up with poor test reliability.

- Using pure tone audiometry is one of the best ways obtain threshold results in children ages 4-5 with poor test reliability.

- I recommend electrophysiological testing to patients that are 65 or older that have less than good test reliability.

The complete survey can be found in the Appendix.

Adding a value to each response on a scale of 1 to 7 allowed for a quantitative analysis that compared responses of audiologists to hearing aid specialists.

Participants

Thirteen audiologists and ten hearing instrument specialists participated in this study. Table 1 below displays the demographics of the participants.

Table I (Participant Demographics)

	Audiologists (AuD)	**Hearing Instrument Specialist (HIS)**
Number of Participants	13	10
Mean Years of Practice	15+ (mode)	1-3 (mode)
Number in a Private Practice	0	4
Number in a Hearing Aid Clinic	3	6
Number in Hospital Setting	3	0
Number in Hospital/HA Clinic	2	0
Number in Private Practice/HA clinic	2	0
Number in Private Practice/Hospital	1	0
Number in Unknown Setting	2	0

Demographics of the participants in the study, 13 audiologists and 10 hearing instrument specialists participated.

Data Analysis

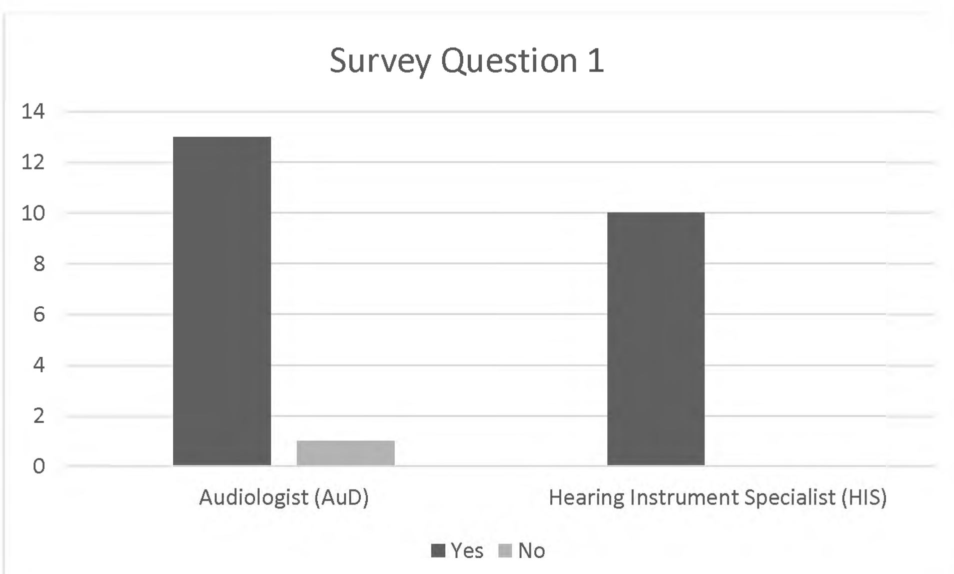
Descriptive statistics was used to summarize the data via a quantitative analysis using an independent samples T-test to compare responses from audiologists and hearing instrument specialists. Each question was answered using a 7-point Likert scale. A t-test is a statistical test that compares the means of two samples. It is used in hypothesis testing, with a null hypothesis indicating that the difference in group means is zero and an alternate hypothesis that the difference in group means is different from zero.

CHAPTER IV

RESULTS

Survey Question 1: I am at least 18 years old and am an audiologist or hearing aid specialist, I understand the information pertaining to the study and want to take part in this study. If the answer is "yes", please proceed to question two. Figure 1 represents the number of participants (AuD's vs. HIS') who are at least 18 years old and are either an audiologist or hearing aid specialist, that understands the information pertaining to this study and want to take part in it.

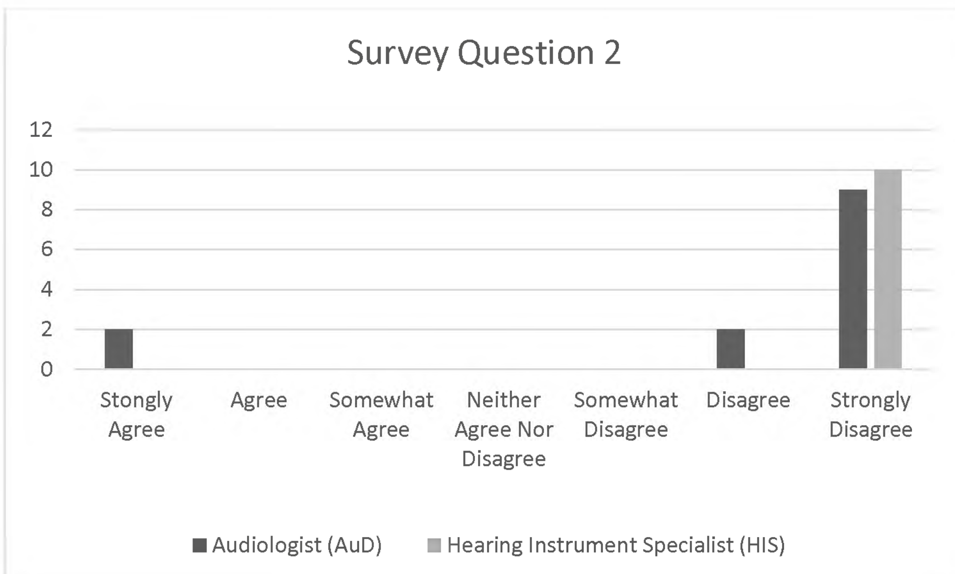
Figure 1



Results of this study showed that only 13 out of 14 (93%) AuD's and 10 out of 10 (100%) HIS were over the age of 18, understood the information pertaining to this study and wanted to partake in it. Since one of the AuD' selected "no" for survey question one, they did not meet the inclusion criteria and were therefore eliminated from the study.

Survey Question 2: I have been practicing in the field for less than a year. Figure 2 represents the number of participants (AuD's vs. HIS') who have been practicing in the field for less than a year.

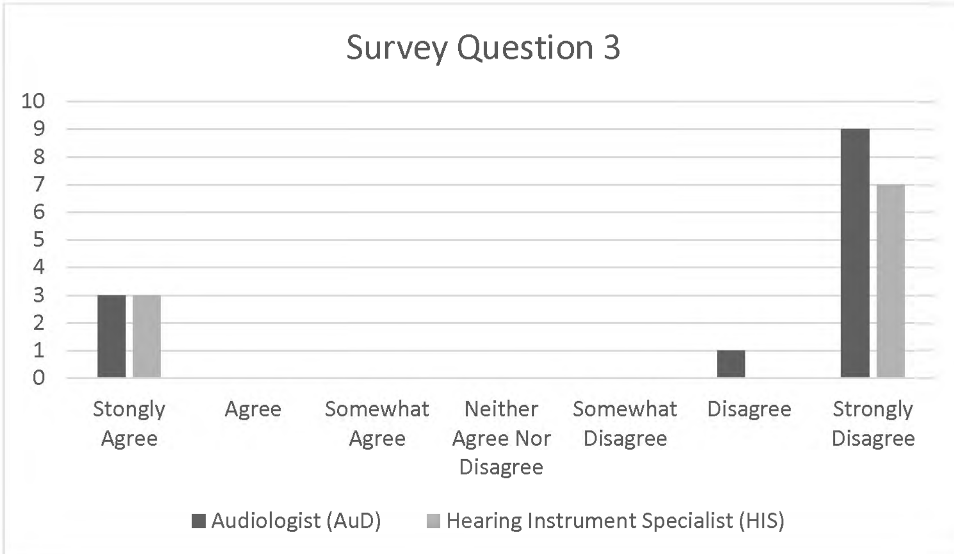
Figure 2



Results of this study showed that 2 out of 13 (15%) Audiologists (AuD) and no Hearing Instrument Specialists from this study (0 out of 10) have been practicing in the field for less than a year.

Survey Question 3: I have been practicing in the field for 1-3 years. Figure 3 represents the number of participants (AuD's vs. HIS') who have been practicing in the field for 1-3 years.

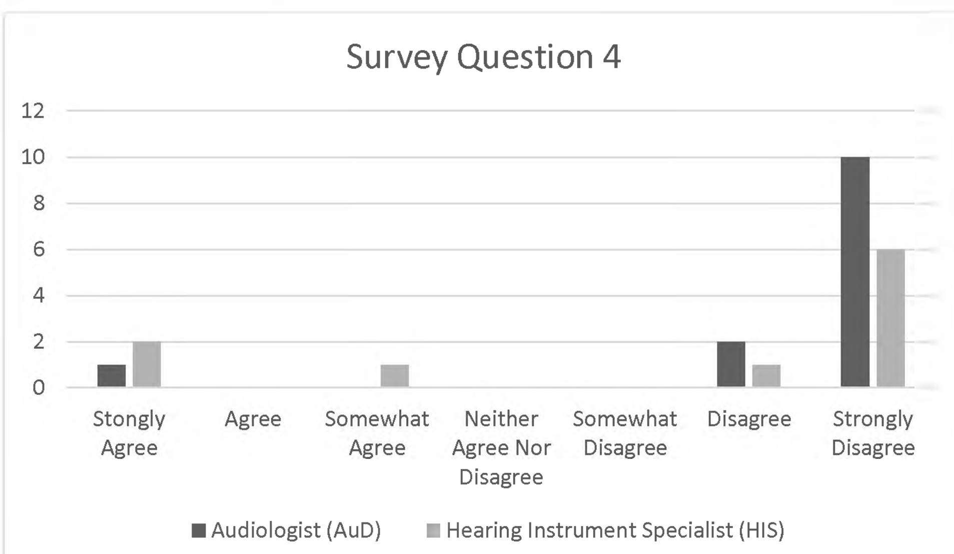
Figure 3



Results of this study showed that 3 out of 13 (23%) Audiologists and 3 out of 10 (30%) Hearing Instrument Specialists have been practicing in the field for 1-3 years.

Survey Question 4: I have been practicing in the field for 5-7 years. Figure 4 represents the number of participants (AuD's vs. HIS') who have been practicing in the field for 5-7 years.

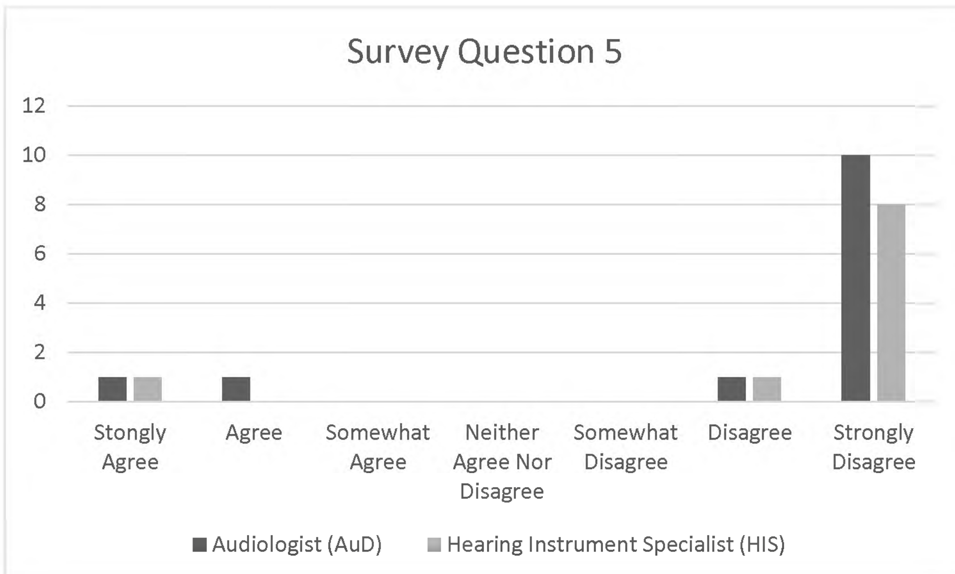
Figure 4



Results of this study showed that 1 out of 13 (8%) Audiologists and 2 out of 10 (20%) Hearing Instrument Specialists have been practicing in the field for 5-7 years.

Survey Question 5: I have been practicing in the field for 7-10 years. Figure 5 represents the number of participants (AuD's vs. HIS') who have been practicing in the field for 7-10 years.

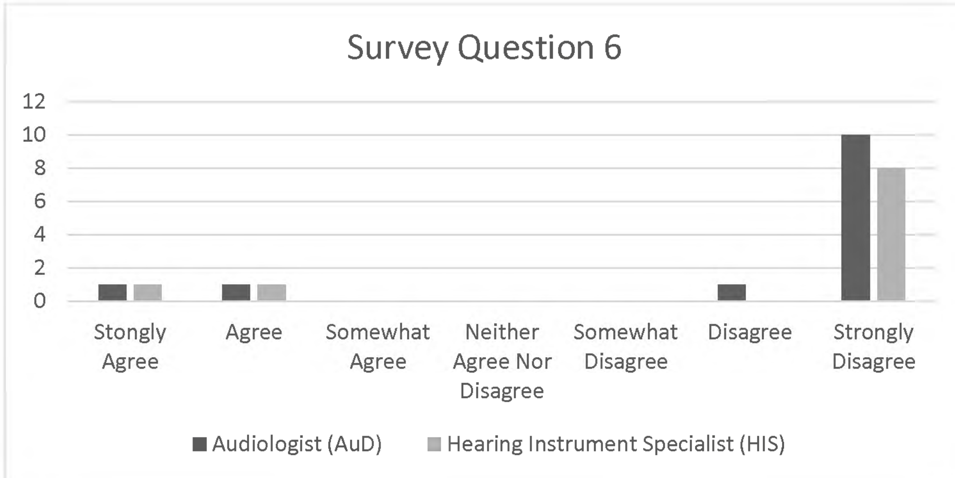
Figure 5



Results of this study showed that 2 out of 13 (15%) Audiologists and 1 out of 10 (10%) Hearing Instrument Specialists "strongly agree" to "agree" that they have been practicing in the field for 7-10 years.

Survey Question 6: I have been practicing in the field for 10-15 years. Figure 6 represents the number of participants (AuD's vs. HIS') who have been practicing in the field for 10-15 years.

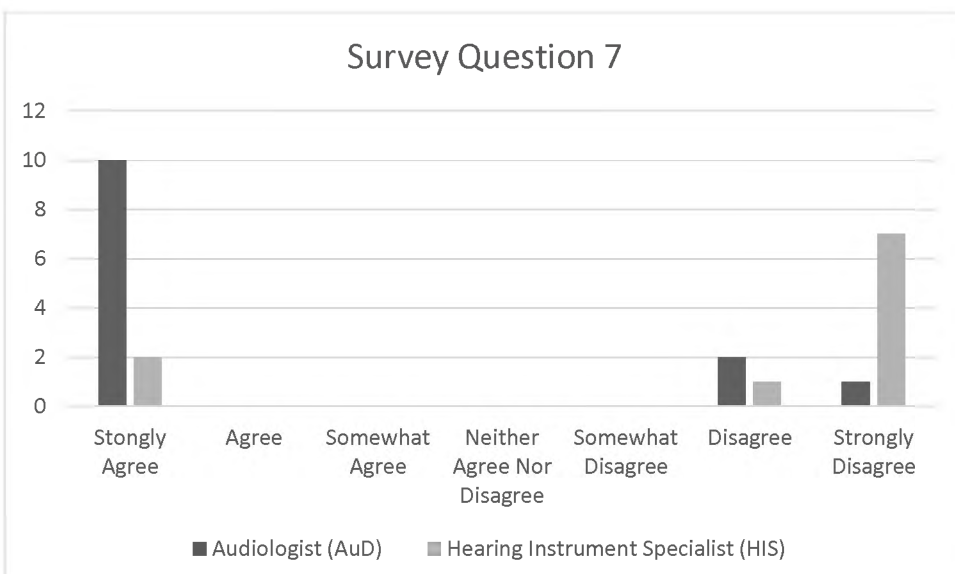
Figure 6



Results of this study showed that 2 out of 13 (15%) Audiologists and 2 out of 10 (20%) Hearing Instrument Specialists "strongly agree" to "agree" that they have been practicing in the field for 10-15 years.

Survey Question 7: I have been practicing in the field for 15 or more years. Figure 7 represents the number of participants (AuD's vs. HIS') who have been practicing in the field for 15 or more years.

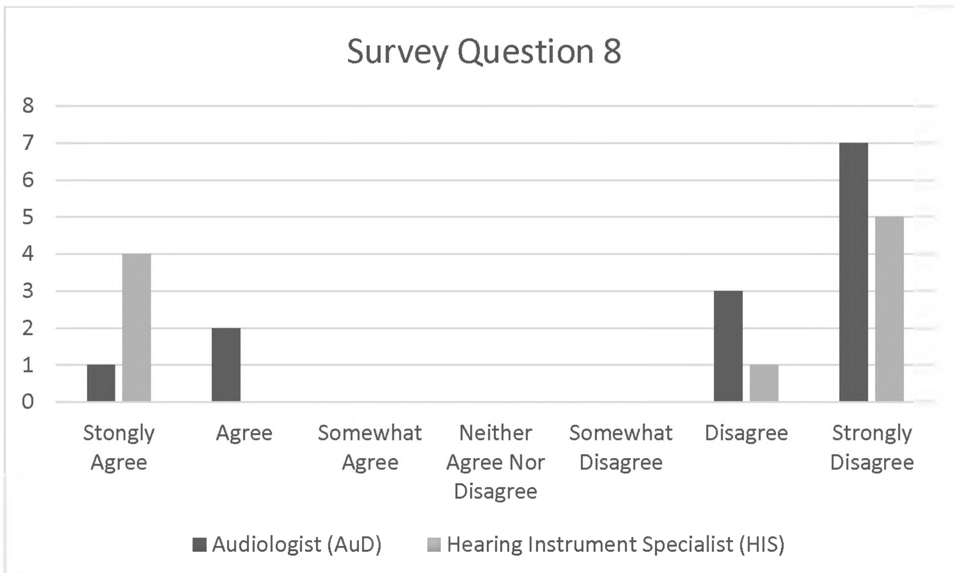
Figure 7



Results of this study showed that 10 out of 13 (77%) Audiologists and 2 out of 10 Hearing Instrument Specialists (20%) have been practicing in the field for 15 or more years.

Survey Question 8: I work in a private practice setting. Figure 8 represents the number of participants (AuD's vs. HIS') who work in a private practice setting.

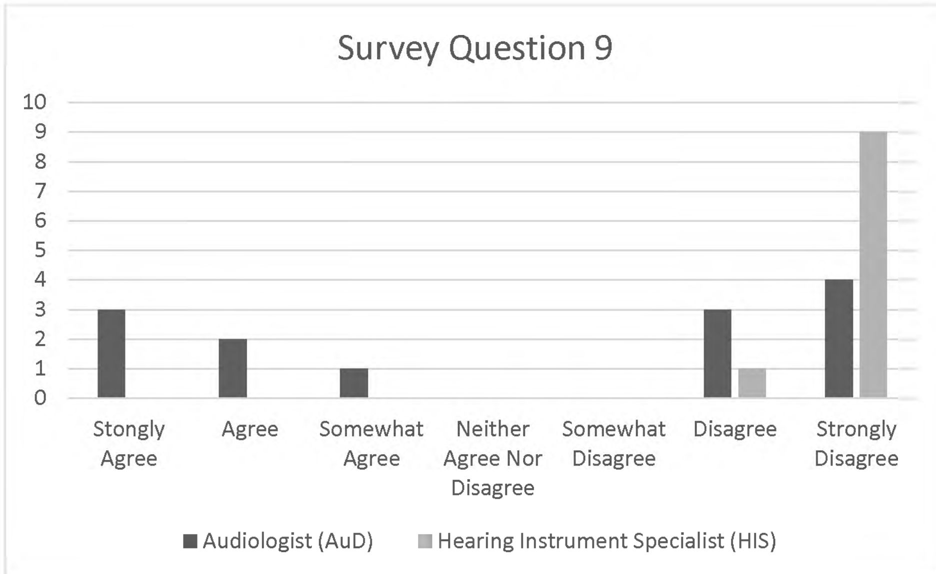
Figure 8



Results of this study showed that 3 out of 13 (23%) Audiologists and 4 out of 10 (40%) Hearing Instrument specialists "strongly agree" to "agree" that they work in a private practice setting.

Survey Question 9: I work in a hospital setting. Figure 9 represents the number of participants (AuD's vs. HIS') who work in a hospital setting.

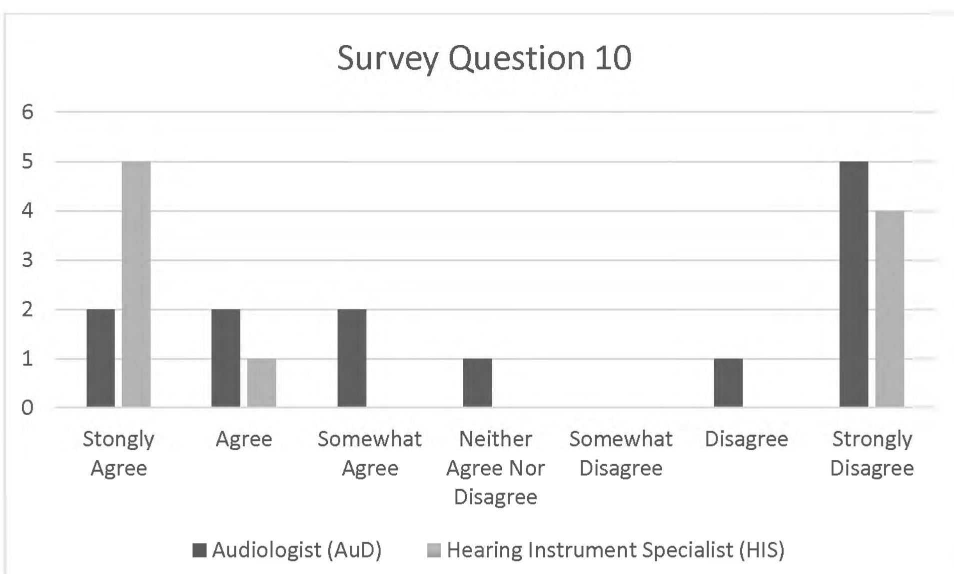
Figure 9



Results of this study showed that 5 out of 13 (38%) of Audiologists "strongly agree" to "agree" and 10 out of 10 (100%) Hearing Instrument Specialists "disagree" to "strongly disagree" that they work in a hospital setting.

Survey Question 10: I work in a hearing aid clinic. Figure 10 represents the number of participants (AuD's vs. HIS') who work in a hearing aid clinic.

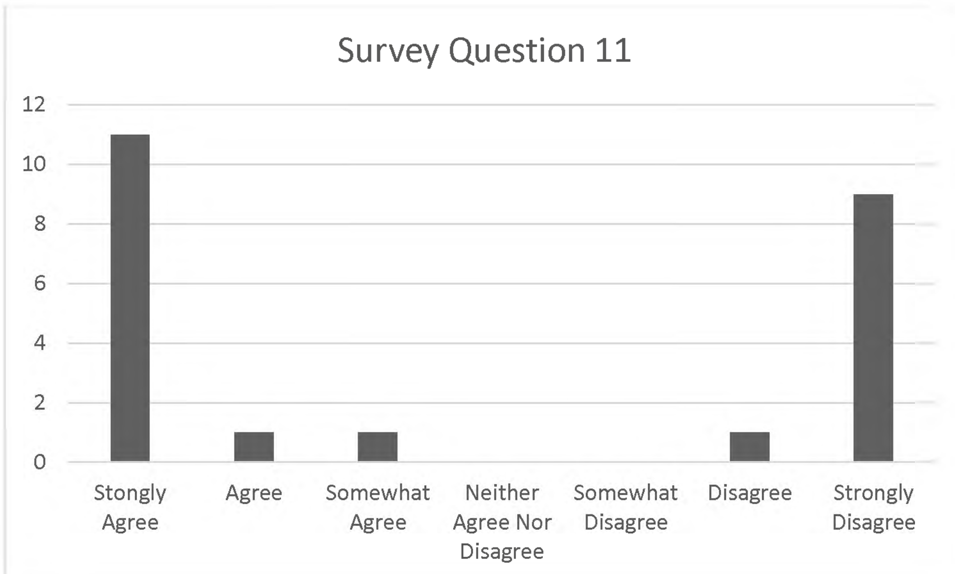
Figure 10



Results of this study showed that 4 out of 10 Audiologists and 6 out of 10 Hearing Instrument Specialists “strongly agree” to “agree” that they work in a hearing aid clinic.

Survey Question 11: My job title is an audiologist. Figure 11 represent the total number of participant’s level of agreeability that their job title is an audiologist (AuD).

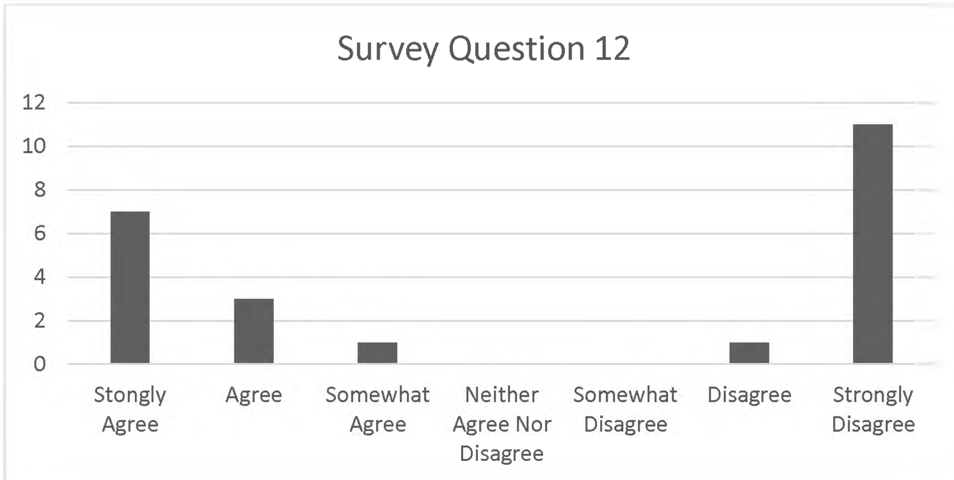
Figure 11



Out of 23 total participants, 13 people “somewhat agreed” to “strongly agreed” that their job title was “Audiologist” (AuD) while 10 people “somewhat disagreed” to “strongly disagreed” that their job title was “Audiologist” (AuD).

Survey Question 12: My job title is a hearing instrument specialist. Figure 12 represent the total number of participant’s level of agreeability that their job title is a Hearing Instrument Specialist.

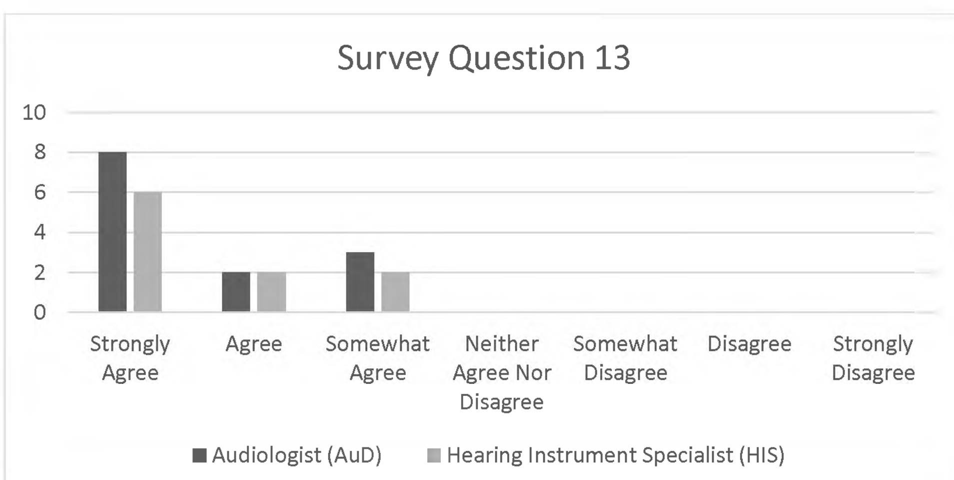
Figure 12



Out of 23 total participants, 11 people "somewhat agreed" to "strongly agreed" that their job title was "Hearing Instrument Specialist" (HIS) while 12 people "somewhat disagreed" to "strongly disagreed" that their job title was "Hearing Instrument Specialist" (HIS).

Survey Question 13: There is a relationship between dementia and hearing loss in the elderly. Figure 13 represents the number of participants (AuD's vs. HIS') level of agreeability that there is a relationship between dementia and hearing loss in the elderly.

Figure 13

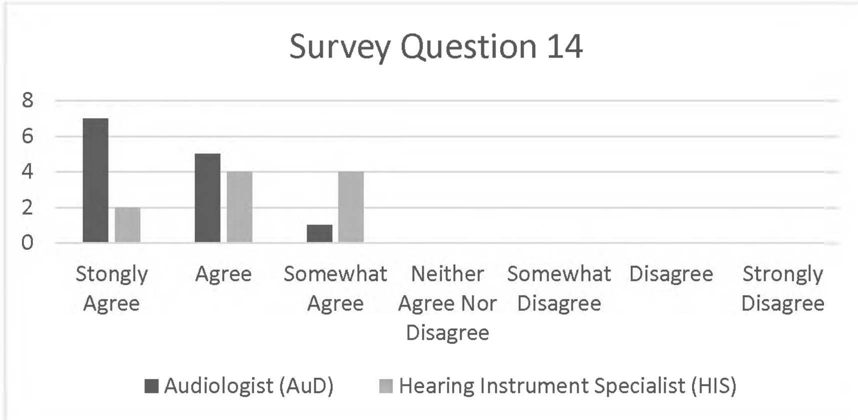


Results of this study showed that 77% of AuD's and 80% of HIS' who participated in this study strongly agree to agree that there is a relationship between dementia and hearing loss in the elderly.

An independent samples t-test was conducted to compare the effects of occupation (AuD vs. HIS) on the amount of agreeability that there is a relationship between dementia and hearing loss in the elderly. There was no statistically significant difference between audiologists and hearing instrument specialists as it relates to their opinion about the whether or not there is a relationship between dementia and hearing loss in the elderly. There was no significant effect for occupation (audiologist vs HIS), $t(21) = .259$, $p = .799$, between the audiologists ($M = 1.692$, $SD = .855$) and hearing aid specialists ($M = 1.60$, $SD=.843$) as both groups average responses fall in the "strongly agree" to "agree" range that there is a relationship between dementia and hearing loss in the elderly.

Survey Question 14: When using pure tone audiometry, I re-test patients that have fair or poor test reliability. Figure 14 represents the number of participants (AuD's vs. HIS') who re-test the hearing in patients that have fair or poor test reliability when using pure tone audiometry.

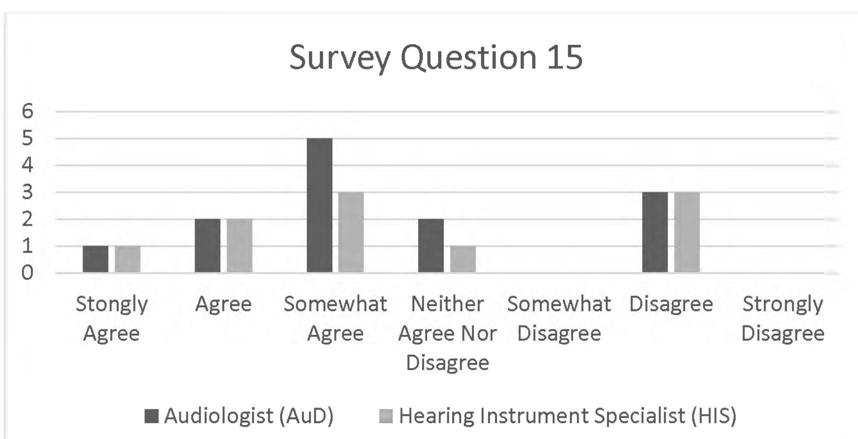
Figure 14



Results of this study showed that 12 out of 13 (92%) Audiologists "strongly agree" to "agree" while 8 out of 10 (80%) Hearing Instrument Specialists "agree" to "somewhat agree" that they re-test the hearing in patients that have fair or poor test reliability when using pure tone audiometry.

Survey Question 15: For patients 65 and older, if there is no response for a certain decibel frequency, I wait for a longer period of time before increasing the decibel level by 5dB. Figure 15 represents the number of participants (AuD's vs. HIS') who wait for a longer period of time before increasing the decibel level by 5dB if there is no response for a certain decibel frequency in patients 65 and older.

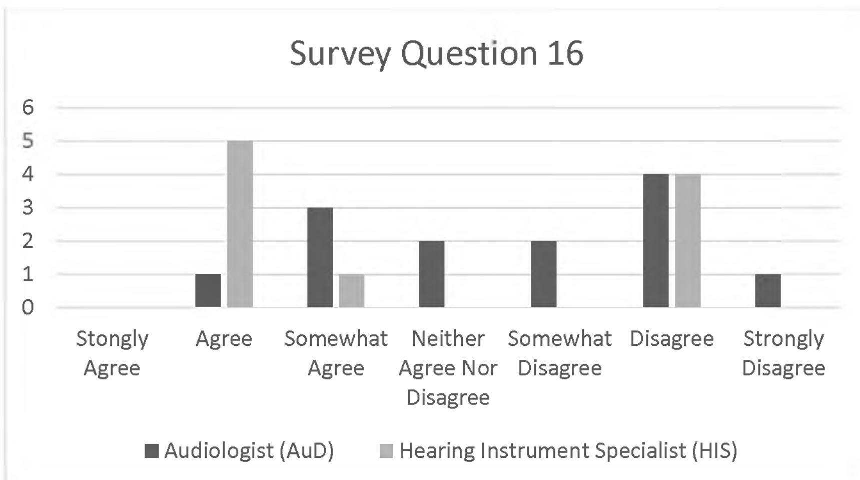
Figure 15



Results of this study showed that 8 out of 13 (62%) Audiologists and 6 out of 10 (60%) Hearing Instrument Specialists "somewhat agree" to "strongly agree" that they wait for a longer period of time before increasing the decibel level by 5dB if there is no response for a certain decibel frequency in patients 65 and older.

Survey Question 16: For patients 65 and older, I wait 3 seconds before increasing the decibel level by 5. The bar graph represents the number of participants (AuD's vs. HIS') who wait 3 seconds before increasing the decibel level by 5 in patients 65 and older.

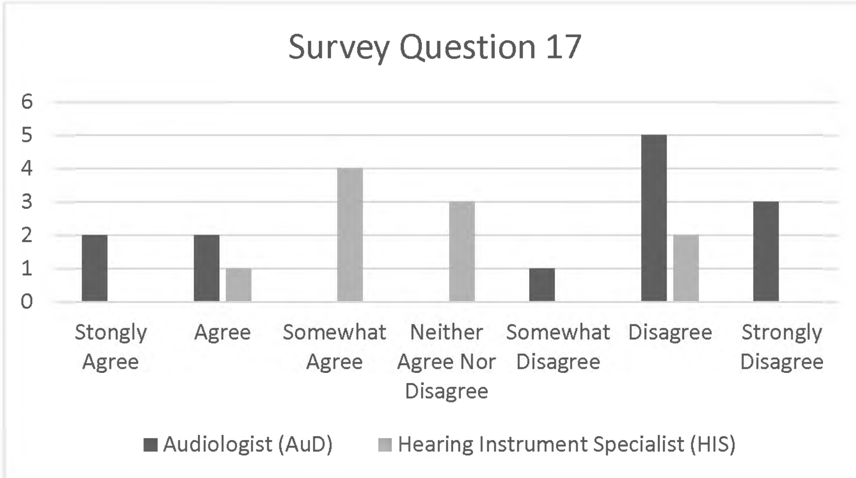
Figure 16



Results of this study showed that 5 out of 13 Audiologists "disagree" to "strongly disagree" while 5 out of 10 Hearing Instrument Specialists "agree" to "strongly agree" that they wait 3 seconds before increasing the decibel level by 5 in patients 65 and older.

Survey Question 17: For patients 65 and older, I wait 5 seconds before increasing the decibel level by 5. Figure 17 represents the number of participants (AuD's vs. HIS') who wait 5 seconds before increasing the decibel level by 5 in patients 65 and older.

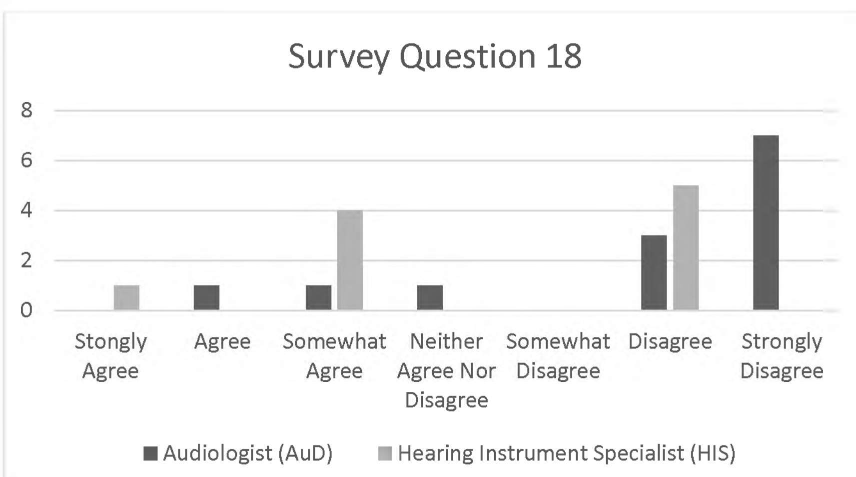
Figure 17



Results of this study showed that 8 out of 13 (62%) Audiologists "disagree" to "strongly disagree" while 7 out of 10 (70%) Hearing Instrument Specialists "somewhat agree" to "neither agree nor disagree" that they wait 5 seconds before increasing the decibel level by 5 in patients 65 and older.

Survey Question 18: For patients 65 and older, I wait 7 seconds before increasing the decibel level by 5. Figure 18 represents the number of participants (AuD's vs. HIS') who wait 7 seconds before increasing the decibel level by 5 in patients 65 and older.

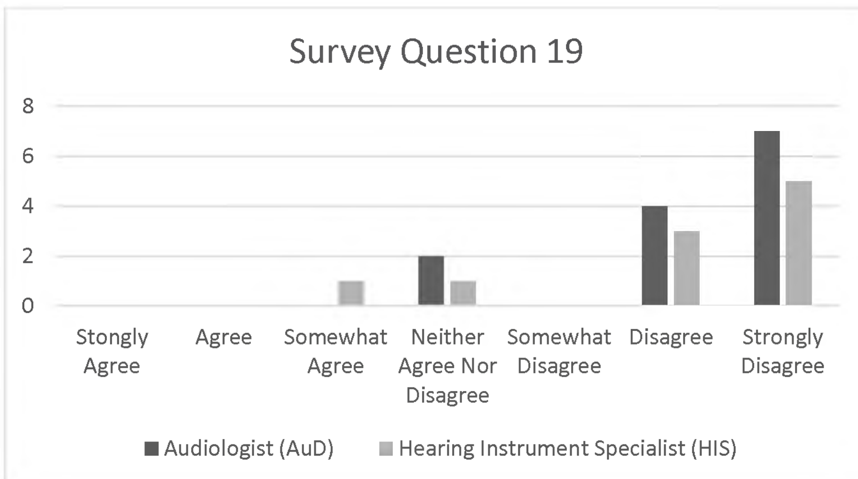
Figure 18



Results of this study showed that 10 out of 13 (77%) Audiologists and 5 out of 10 (50%) Hearing Instrument Specialists "disagree" to "strongly disagree" that they wait 7 seconds before increasing the decibel level by 5 in patients 65 and older.

Survey Question 19: For patients 65 and older, I wait 10 seconds before increasing the decibel level by 5. Figure 19 represents the number of participants (AuD's vs. HIS') who wait 10 seconds before increasing the decibel level by 5 in patients 65 and older.

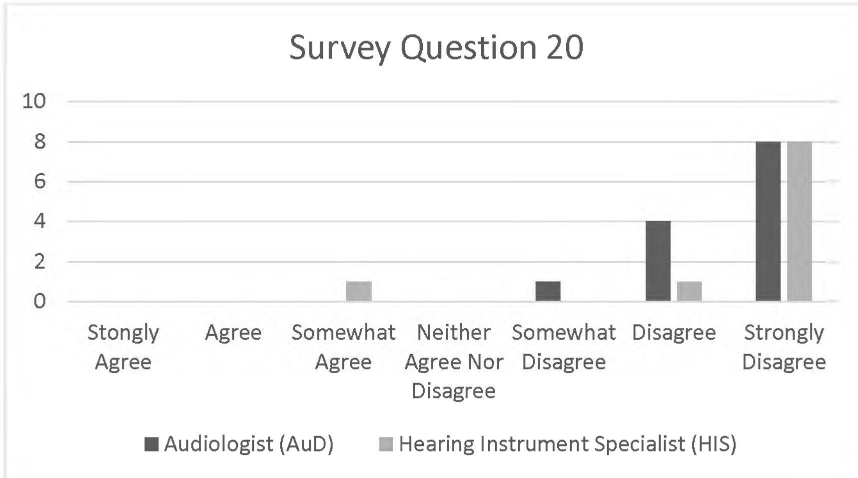
Figure 19



Results of this study showed that 11 out of 13 (85%) Audiologists and 8 out of 10 (80%) Hearing Instrument Specialists "disagree" to "strongly disagree" that they wait 10 seconds before increasing the decibel level by 5 in patients 65 and older.

Survey Question 20: For patients 65 and older, I wait more than 10 seconds before increasing the decibel level by 5. Figure 20 represents the number of participants (AuD's vs. HIS') who wait more than 10 seconds before increasing the decibel level by 5 in patients 65 and older.

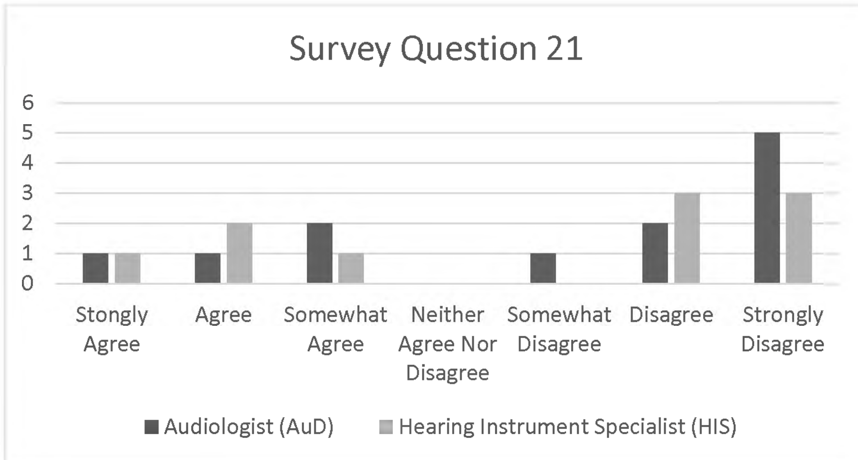
Figure 20



Results of this study showed that 12 out 13 (92%) Audiologists and 9 out of 10 (90%) Hearing Instrument Specialists "disagree" to "strongly disagree" that they wait more than 10 seconds before increasing the decibel level by 5 in patients 65 and older.

Survey Question 21: Hypothetical situation: A patient who has not had their hearing tested in over a year comes in and requests that you increase the gain on their hearing aids. You increase the gain based on the old audiogram. Figure 21 represents the number of participants (AuD's vs. HIS') who adjust the hearing aid of patient who has not had their hearing tested in over a year based on their old audiogram.

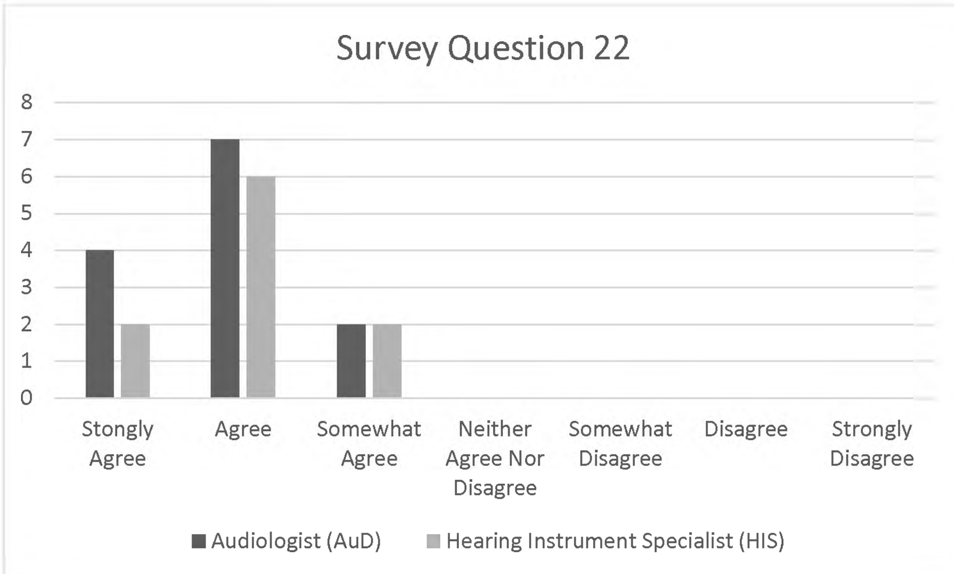
Figure 21



Results of this study showed that 7 out of 13 (54%) Audiologists and 6 out of 10 (60%) Hearing Instrument Specialists "disagree" to "strongly disagree" that they adjust the hearing aid of patient who has not had their hearing tested in over a year based on their old audiogram.

Survey Question 22: Hypothetical situation: A patient who has not had their hearing tested in over a year comes in and requests that you increase the gain on their hearing aids. You re-test the patient's hearing and increase the gain based on the new hearing test. Figure 22 represents the number of participants (AuD's vs. HIS') who re-test the hearing of patients who are requesting a gain increase on their hearing aids when they have not had their hearing tested in over a year.

Figure 22

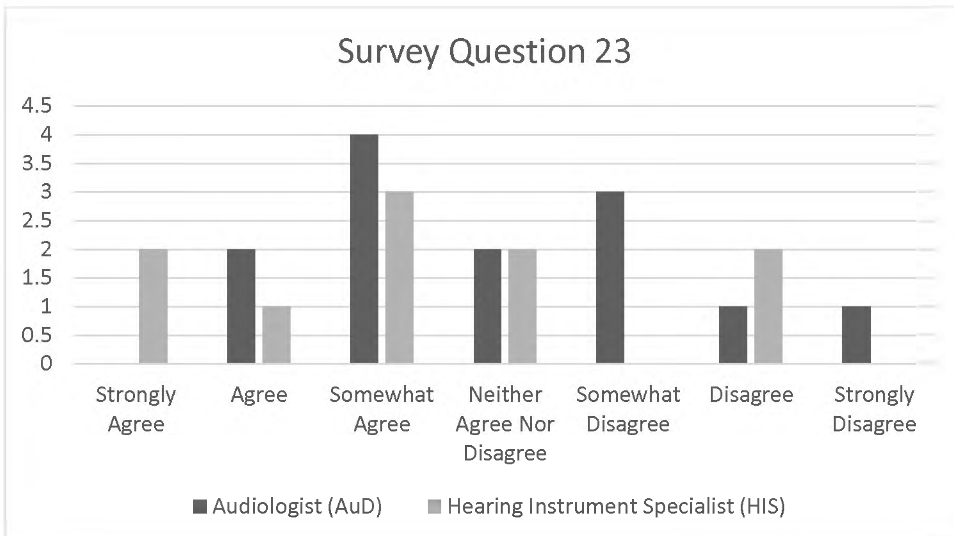


Results of this study showed that 11 out of 13 (85%) Audiologists and 8 out of 10 (80%) Hearing Instrument Specialists "agree" to "strongly agree" that they re-test the hearing of patients who are requesting a gain increase on their hearing aids when they have not had their hearing tested in over a year.

Survey Question 23: Using pure tone audiometry is one of the best ways to obtain accurate threshold measures in patients 65 and up with poor test reliability. An independent samples t-test was conducted to compare the effects of occupation (AuD vs. HIS) on the amount of agreeability that pure tone audiometry is one of the best ways to obtain accurate threshold measures in patients 65 and up with poor test reliability. There was no statistically significant difference between audiologists and hearing instrument specialists as it relates to their opinion about the whether or not pure tone audiometry is an effective technique to measure thresholds in patients age 65 and older who have poor test reliability. There was no significant effect for occupation (audiologist vs HIS), t (21) = 1.018, p = .320, despite the audiologist (M = 4.00, SD = 1.52) providing a neutral response, neither agree nor disagree compared to the hearing aid specialists (M = 3.33) which corresponds closely to somewhat agree.

Figure 23 represents the number of participants (AuD's vs. HIS') level of agreeability that using pure tone audiometry is one of the best ways to obtain accurate threshold measures in patients 65 and up with poor test reliability.

Figure 23



Results of this study showed that 31% of AuD's and 30% of HIS' of the participants in the survey only "somewhat agreed" that using pure tone audiometry is one of the best ways to obtain accurate threshold measures in patients 65 and up with poor test reliability. Results show that AuD's and HIS' are in similar agreement that not all patients are not good candidates for pure tone audiometry, specifically patients age 65 and up with poor test reliability.

Survey Question 24: Using pure tone audiometry is one of the best ways to obtain threshold results in children ages 4-5 with poor test reliability.

Table II (Independent Samples T-Test)

	t	df	Sig (2-tailed)
Equal variances assumed	2.103	21	.048

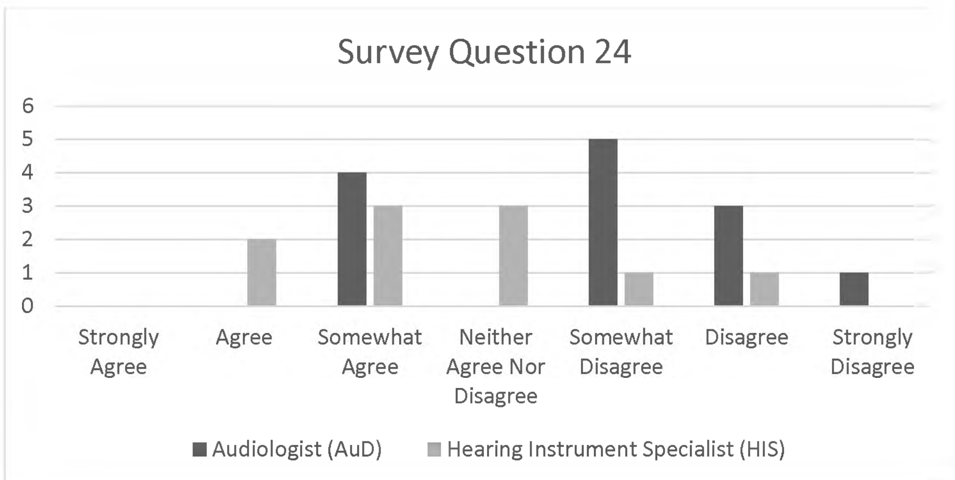
Table III (Group Statistics)

Occupation	**Group Size**	**Mean**	**Std. Deviation**	
Audiologists	13	4.7692	1.36344	
Hearing Instrument Specialists	10	3.6000	1.26491	

An independent samples t-test was conducted to compare the effects of occupation (AuD vs. HIS) on the amount of agreeability that using pure tone audiometry is one of the best ways to obtain threshold results in children ages 4-5 with poor test reliability. There was a statistically significant difference between audiologists and hearing instrument specialists as it relates to their opinion about pure tone audiometry being one of the best ways to obtain threshold results in children ages 4-5 with poor test reliability. There was significant effect for occupation (audiologist vs HIS), t (21) = 2.103, p = .048, despite the audiologist (M = 4.769, SD = 1.36) providing a “neither agree nor disagree” to “somewhat disagree” compared to the hearing aid specialists (M = 3.60) which corresponds closely to “somewhat agree”. Differences in results may be due to the fact that Hearing Instrument Specialists are not eligible to test the hearing in patients under the age of 18 and thus therefore lack experience with this population, while audiologists can test both pediatric and geriatric populations and thus have more knowledge to apply towards both groups.

Figure 24 represents the number of participants (AuD's vs. HIS') level of agreeability that using pure tone audiometry is one of the best ways to obtain threshold results in children ages 4-5 with poor test reliability.

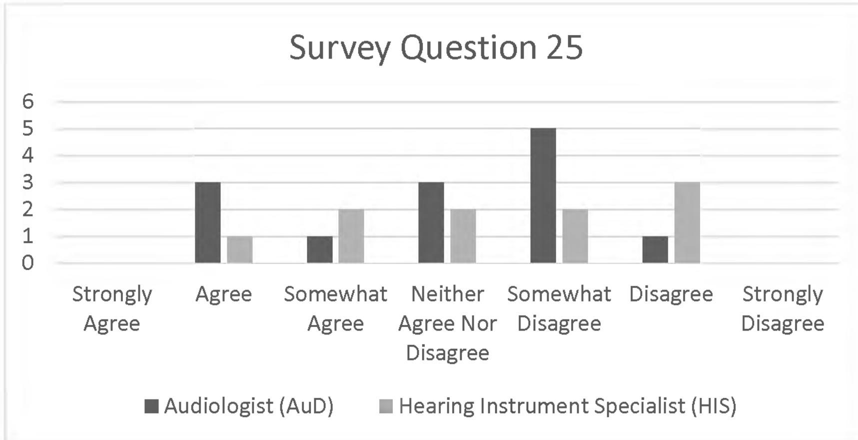
Figure 24



Results of this study showed that 38% of AuD's somewhat disagree, while 40% of HIS' somewhat agree that using pure tone audiometry is one of the best ways to obtain threshold results in children ages 4-5 with poor test reliability.

Survey Question 25: "I recommend electrophysiological testing to patients that are 65 or older that have less than good test reliability". Figure 25 represents the number of participants (AuD's vs. HIS') level of agreeability to recommend electrophysiological testing to patients that are 65 or older that have less than good test reliability.

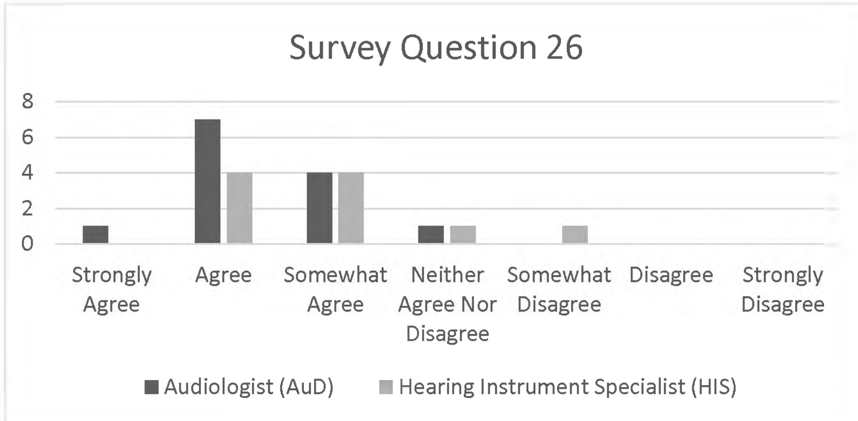
Figure 25



Results of this study showed that 46% of AuD's and 50% of HIS' somewhat disagree to disagree that they recommend electrophysiological testing to patients that are 65 or older that have less than good test reliability. What this means is half of the hearing professionals from this study do not recommend electrophysiological testing to patients that are 65 and older that have less than good test reliability.

Survey Question 26: I recommend electrophysiological testing to patients that are age 4 to 5 that have less than good test reliability. Figure 26 represents the number of participants (AuD's vs. HIS') level of agreeability to recommend electrophysiological testing to patients that are age 4 to 5 that have less than good test reliability.

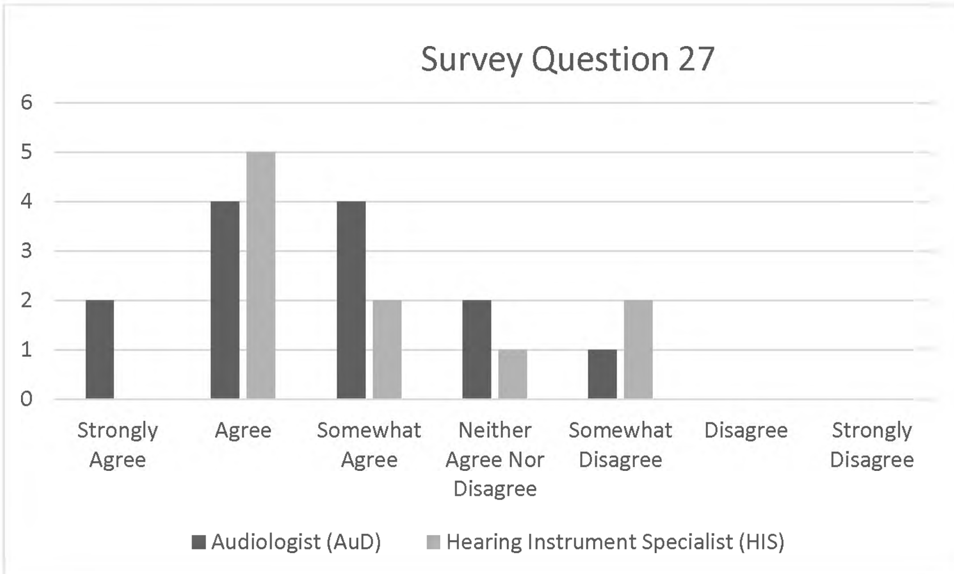
Figure 26



Results of this study showed that 84% of AuD's and 80% of HIS' agree to somewhat agree that they would recommend electrophysiological testing to patients that are age 4 to 5 that have less than good test reliability.

Survey Question 27: Hypothetical Question: A patient comes in complaining that their hearing aids are too loud, so you retest the patient's hearing. Retest results show that there has been no change in hearing across frequencies from the previous audiogram. You adjust the gain on the hearing aid based upon the patient's subjective most comfortable listening level (MCL). Figure 27 represents AuD's and HIS' response to the following hypothetical question: "A patient comes in complaining that their hearing aids are too loud, so you retest the patient's hearing. Retest results show that there has been no change in hearing across frequencies from the previous audiogram. You adjust the gain on the hearing aid based upon the patient's subjective most comfortable listening level (MCL)".

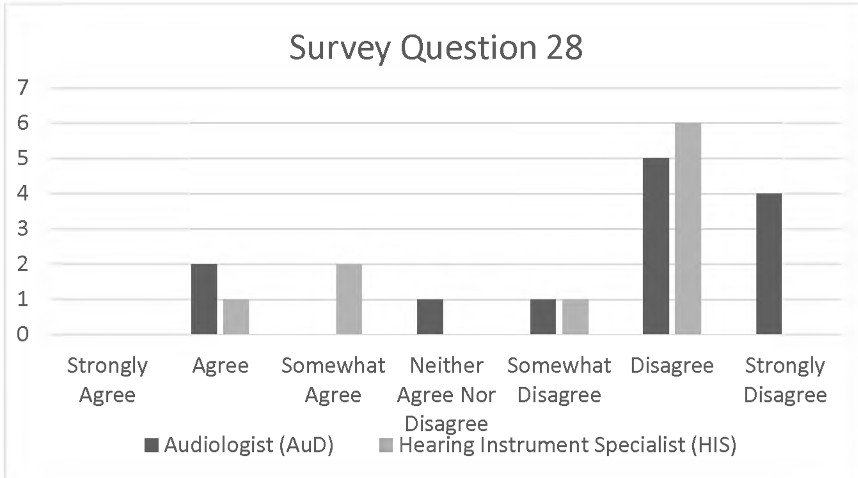
Figure 27



Results of this study showed that 62% of AuD's and 70% of HIS' agreed-somewhat agreed that they would retest a patient's hearing if the patient was complaining that their HA's were too loud. They also agreed-somewhat agreed that if re-test results showed that there had been no change in hearing across frequencies from the previous audiograms, they would adjust the gain on the hearing aid based upon the patient's subjective most comfortable listening level (MCL). What this means is that a little less than 3/4ths of hearing professionals from this study are basing hearing aid programing on subjective data measures.

Survey Question 28: "I typically provide a cognitive screening for clients over the age of 65". Figure 28 represents the number of participants (AuD's vs. HIS') level of agreeability to provide cognitive screenings for clients over the age of 65.

Figure 28



Results of this study showed that 69% of AuD's and 60% of HIS' disagree to strongly disagree that they provide cognitive screenings to clients over the age of 65. What this means is that only a little over a 1/4th of hearing professionals from this study are providing cognitive screenings to patients over the age of 65.

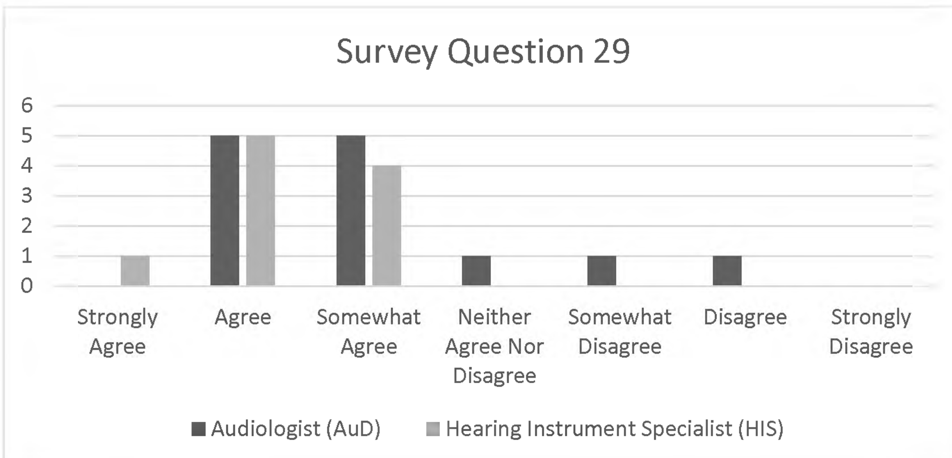
Survey Question 29: I have questioned the reliability of the patient's responses who were over the age of 65 and were demonstrating signs of cognitive decline.

An independent samples t-test was conducted to compare the effects of occupation (AuD vs. HIS) on the amount of agreeability that they have questioned the reliability of the patient's responses who were over the age of 65 and were demonstrating signs of cognitive decline. There was not a statistically significant difference between audiologists and hearing instrument specialists as it relates to their opinion about questioning the reliability of the patient's responses who were over the age of 65 and were demonstrating signs of cognitive decline. There was no significant effect for occupation (audiologist vs HIS), t (21) = 1.764, p = .092, despite the audiologist (M =

3.0769 SD = 1.256) providing a “somewhat agree” compared to the hearing aid specialists (M =2.3) which corresponds closely to “agree”.

Figure 29 represents the number of AuD’s and HIS’ from this study who questioned the reliability of their patient’s responses who were over the age of 65 and were demonstrating signs of cognitive decline.

Figure 29



Results of this study showed that 77% of AuD’s and 90% of HIS’ either somewhat to strongly agree that they have questioned the reliability of their patient’s responses who were over the age of 65 and were demonstrating signs of cognitive decline. This means that over 3/4ths of the hearing professionals from this survey do not feel confident in accuracy of their patient’s responses who are over the age of 65 and demonstrating signs of cognitive decline.

Survey Question 30: Is there any additional information that you can provide related to audiometric testing for patients over the age of 65 who may have cognitive decline. For question 30 there were several different responses obtained from both hearing instrument specialists (HIS’) and Audiologists (AuD’s). Below are the responses obtained.

1: “For the last question, I really only question the reliability of responses if the PTA and SRT does not line up. If they are inconsistent with pressing the button for responding (or I see that the PTA/SRT do not align), I switch to having them say 'yes' when they hear the tone and 'no' when they don't. This typically allows me to get a softer threshold because they say 'no' when they heard it but they believe it too soft for their preference. They may not recognize (due to the cognitive decline) that by their response of 'no' they are giving me exactly what I need. Children can behave in a similar fashion”. - AuD in a HA clinic

2: “If the results can be validated and reliable regardless of cognitive ability than I would not question the results”. -AuD in a HA clinic

3. “I think we can determine when a patient is unreliable and adjust our behavioral testing techniques accordingly”. -AuD in a HA clinic

4. “Consistency of responses are good indicators for test reliability”. -AuD in a hospital/HA clinic

5. “Warble, pulsed stimuli are helpful for this population”. -AuD in a hospital/private practice

6. “Just work slowly. Get feedback from family on their cognitive ability . Do a quick cognitive screening if time allows. Always do speech mapping. Always do a repeat test especially yearly. Do WRS slowly and binaurally”.-AuD in a private practice/HA clinic

7. “I usually trust the responses that I get from my clients”.- HIS in a HA clinic

8. “You just need to give them a little time, but not an unusually long time to respond”. - HIS in a HA clinic

9. “We have to believe what the patients are telling us”. -HIS in a HA clinic

CHAPTER V

DISCUSSION AND RECOMMENDATIONS

The purpose of this study was to examine the professional practices and attitudes of HIS and audiologists as it relates to the assessment of hearing in the elderly population. This study also examined whether or not these hearing care professionals (AuD's and HIS') acknowledge an association between hearing loss and cognitive decline in the elderly, to determine if there is a difference in the manner in which these hearing professionals allow for challenges in behavioral testing of elderly clients, and to determine whether or not additional audiological assessment is sought for geriatric patients, such as electrophysiological testing when behavioral testing yields unreliable responses from elderly clients.

This study was guided by the following research questions:

1.Do audiologists and hearing aid specialists acknowledge an association between hearing loss and cognitive decline in the elderly?

2. Is there a difference in the manner in which audiologist vs. hearing instrument specialists allow for challenges in behavioral testing of elderly clients?

3. Do audiologist and hearing instrument specialists refer elderly clients for electrophysiological testing when behavioral testing reveals unreliable responses from elderly clients?

This chapter will discuss the findings as they relate to each research question.

The first research question focused on whether or not audiologists and hearing aid specialists acknowledge an association between hearing loss and cognitive decline in the elderly.

Results from this study showed that 77% of AuD's and 80% of HIS' acknowledge an association between hearing loss and cognitive decline in the aging population. This finding is consistent with the literature that documents the association between cognitive decline and hearing loss in the elderly (Lin, 2015).

The second research question explored whether or not there was a difference in the manner in which audiologist vs. hearing instrument specialists allow for challenges in behavioral testing of elderly clients.

During behavioral audiometry, the clinician presents a beeping sound and asks the client to raise their hand or press a button when the sound is heard. The clinician is trying to establish thresholds for each frequency, or the lowest intensity level at which an individual is barely able to detect the presence of a tone. The question about whether or not professionals allow for challenges in behavioral testing of elderly clients was explored through survey questions 15 - 20 that asks "if there is no response for a certain decibel frequency, I wait for a longer period of time before increasing the decibel level by 5 dB." Questions 16 – 20 are somewhat redundant in that the questions ask if the clinician waits 3 seconds, 5 seconds, 7 seconds, 10 seconds, or longer than 10 seconds before raising the decibel level by 5 dB. The rationale behind this question was due to the slowed psychomotor response of elderly individuals who may be experiencing cognitive decline. Responding by behaviorally raising the hand or pressing the button may be done, but it could be in a delayed fashion after hearing the beeping tone.

A majority of clinicians (92.39 %) agreed that they wait for a longer period of time before increasing the decibel level by 5 dB. However, when the following questions asked about how long the clinician waits before raising the intensity of the sound (assuming that the sound was not audible to the listener), the results varied widely.

A t-test of independent samples showed that there was no statistical difference in the manner in which audiologist vs. hearing instrument specialists allow for challenges in behavioral testing of elderly clients. The variability among audiologists and HIS imply that there is no standard protocol for determining an acceptable "wait time" before assuming that the client did not hear the tone, and therefore increasing the tone by 5 dB.

The third research question explored whether or not audiologists and hearing instrument specialists refer elderly clients for electrophysiological testing when behavioral testing reveals unreliable responses from elderly clients. This question has several interesting implications.

This study found that 84% of AuD's and 80% of HIS' agree to somewhat agree that they would recommend electrophysiological testing to patients that are age 4 to 5 that have less than good test reliability. However, 54% of AuD's and 50% of HIS' agree that they recommend electrophysiological testing to patients that are 65 or older that have less than good test reliability. Why would electrophysiological testing be recommended for children when results are unreliable, but not for elderly individuals?

If hearing aid fittings are based upon unreliable behavioral results that have not been validated by electrophysiological testing, then the hearing aid settings may be inappropriate. This could lead to inconsistent or non-use of hearing aids. The uncertainty in the behavioral results may be the primary reason for elderly individuals indicating that their hearing instruments are too loud, noisy, or why they report a general dissatisfaction with the overall sound quality of the instrument (Kochkin et al., 2000).

Data from the open-ended question at the end of the survey that asked if there was any additional information AuD's or HIS' could provide related to audiometric testing for patients over the age of 65 who may have cognitive decline, a variety of responses were provided. A vast majority of responses showed that hearing professionals from this study are not questioning behavioral response testing results obtained from the aging population. One audiologist stated "if the results can be validated and reliable regardless of cognitive ability than I would not question the results". Two hearing instrument specialists stated that they have to "trust or believe what patients are telling them." These responses show that the hearing professionals from this study are dedicated to the results provided by behavioral audiometry. In doing so, they might be neglecting a potential cognitive component when performing behavioral response testing that could impact results, but yet are taking these potentially inaccurate subjective results for face value.

The only question that yielded a statistically significant difference between AuDs and HIS was for the question that asked how they would account for poor test reliability in children 4-5 years of age. Results showed that about 40% of AuD's somewhat disagree that pure tone audiometry is the best way to test children age 4-5 with poor test reliability while 40% of HIS' somewhat agreed that pure tone audiometry was one of the best ways to obtain threshold results in children ages 4-5 with poor test reliability. Differences in results may be due to the fact that Hearing Instrument Specialists are not eligible to test the hearing in patients under the age of 18 and thus therefore lack experience with this population, while audiologists can test both pediatric and geriatric populations and thus have more knowledge to apply towards both groups.

If a little less than half of AuD's are acknowledging that subjective results from children ages 4-5 can be inaccurate, why are they failing to acknowledge that results can also be inaccurate with the aging population if a cognitive deficit is present? Roughly 66% of hearing professionals from both groups reported that they felt as though pure tone audiometry was not one of the best ways to obtain accurate threshold measures in the geriatric population and that they did not feel confident in accuracy of their patient's responses who are over the age of 65 and demonstrating signs of cognitive decline on subjective testing measures. Despite both groups reporting lack of confidence in patients results on behavioral response testing measures, question 30 from the survey showed that both groups of professionals actually felt confident in behavioral response testing measures by not questioning results. Despite knowing cognitive deficits exist in this aging population, both parties are still using behavioral response testing measure on patients with less than good test reliability and fitting them with hearing aids based on these potentially inaccurate subjective responses because results show they are not questioning results.

Approximately 80% of hearing professional from this study acknowledged that cognitive deficits may be present in the aging population. Only about a 1/3rd of the professionals agreed that using pure tone audiometry is one of the best ways to obtain accurate threshold measures in patients 65 and up with poor test reliability. Over 3/4ths of the professionals agree that they do not feel confident in accuracy of their patient's responses who are over the age of 65 and demonstrating signs of cognitive decline on subjective testing measures. Despite lack of confidence in subjective testing procedures and results, both parties fail to adapt testing procedures or make referrals to obtain accurate threshold measures in this geriatric population. The results of this study show a strong need to standardize testing procedures for all hearing professionals when testing adults age 65 and up when a cognitive deficit may be present as no standard currently exists.

Another interesting finding from this study was that only 23.53% of hearing professionals provide cognitive screenings for clients over the age of 65. If an overwhelming majority of hearing professions (more than 90%) agree that there is a relationship between hearing loss and cognitive decline in the elderly, why are only 23% of hearing professionals screening for this disability.

We are living in an era with a population whose average age is increasing (Shen et al., 2016). According to the U.S. Department of Health and Human Services, in 2009, 13% of people in the United States were age 65 years and older. This percentage is projected to increase to 19.3% by 2030. Due to the co-existing condition of cognitive decline in the aging population, it is likely that a large number of audiology clients may be affected by age related hearing loss and degrading cognitive abilities.

Several researchers have pushed for the addition of screening for cognitive decline by HIS and AuDs as recommendations for best practice and ensuring the provision of patient centered care (Shen et al., 2016).

Hearing instrument specialists and audiologists can include questions in the case history that focus on memory and depression. The professionals should be alert for signs of inappropriate responses during communication exchanges.

It is also important to communicate with the client's family members to determine if the client has been forgetful or if there has been a change in behavior that might be indicative of a cognitive disorder. These strategies can provide valuable information about the potential cognitive decline an individual might have. This information can also assist the clinician in making a decision about whether a direct measure of cognition is needed.

There are also many cognitive screening tests available to directly assess and quantify cognitive functioning (Lin et al., 2013). Tests that can be used in any clinical setting include the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005). These tests can be administered in a short period of time (10 minutes) and have good psychometric properties of sensitivity and specificity. It should be noted that audiologists and HIS do not diagnose cognitive deficits. Physicians and speech-language pathologists are critical for diagnosing cognitive impairment.

However, audiologists and HIS may be the first to encounter an elderly person who might have a cognitive disorder, and as such it is important that people who seek their services receive the best care to treat the hearing loss. It is recommended that all hearing healthcare professionals provide cognitive screenings for patients age 65 and up where a cognitive deficit may be present and to make referrals accordingly if the patient fails the cognitive screening.

This study also revealed that behavioral audiometry may yield results that do not have good test reliability. A specialized standard of care needs to be developed to help promote a uniform test procedure for all hearing care professionals that will de-mystify the protocol for behavioral assessment of clients aged 65 years and older who might be demonstrating cognitive decline. Proper detection and treatment of hearing loss and cognitive decline is an essential in providing quality comprehensive service to aging adults.

More importantly, if proper detection and intervention is provided, audiologists and hearing instrument specialist can play a critical role in improving the quality of life of the clients they serve by providing more accurate testing results. More accurate results will lead to better fitting hearing aids which in turn will increase the number of elderly people who are actually using their hearing aids. Amplification has been shown to slow the progression of cognitive decline and enhance overall communication skills in elderly adults. Taking the extra steps by referring for electrophysiological testing to confirm thresholds when reliability is in doubt ensures that our elderly clients are receiving the highest level of hearing health care. Only then can professionals in communication sciences and disorders be certain that we have lived up to the mission stated by the American Speech-Language-Hearing Association: Making effective communication, a human right, accessible and achievable for all.

Although there were 112 emails sent to hearing professions, only 23 responses were obtained. I suspect this is due to the fact that several professionals were either be working remotely, may only be in the office a limited number of days or may have extremely busy schedules which therefore which left them with limited access their emails in order to complete the surveys sent. Additionally, I suspect that this survey yielded a low response rate secondary to its length. The sample lacks diversity in the sense that the participants were only from 4 out of 50 different states. Licensure requirements for hearing professionals vary state to state and these differences can yield different responses from professionals. With more diversity in responses this could impact the significance of our results, providing a stronger relationship or a less significant one.

Another limitation to this study is the fact I am a novice research and could have re-phrased or asked different questions in the study to yield more descriptive results such as providing more open-ended questions in the survey to see what these hearing professionals specifically do to account for cognitive deficits. One of my survey questions could have asked if the hearing professionals have every tested the hearing of someone with a known cognitive deficit and how they had to adapt testing procedures for this patient over time. Additional participants in the sample size could impact the significance of the results, providing a stronger relationship or a less significant one. This study was non-longitudinal and therefore an inventory on how these professionals account for cognitive deficits in patients over time was not assessed.

A hearing aid (HA) satisfaction inventory would be useful to have in future studies as a lot of people assume that people don’t wear HA’s for cosmetic/vanity reasons, however it is more about the benefit from them. If the HA’s are too loud because hearing is over diagnosed secondary to hearing professionals not accounting for cognitive deficits and a generalized slowing, then patients experience this perceived loudness causing them to wear HA’s less and in turn this causes a further progression of hearing loss, money wasted, social isolation, and depression.

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APPENDIX

Survey Questions

Is Hearing Loss over-diagnosed due to impaired Cognition in Elderly Patients?

Q1 We are Drs. Cox, Wilhite, and Emilee Witt. We are from the Speech and Hearing Program at Cleveland State University. We are gathering information to find out if cognitive deficits affect the testing of hearing. We have a survey for people who have experienced testing hearing of elderly people such as audiologists and hearing aid specialists that will help us explore this area. Your participation is voluntary. You may withdraw at any time without penalty. We agree to protect your privacy. We will not share your information with anyone outside of this study. We will not ask for your name. Your responses will in no way identify you. There is no reward or direct benefit for participating in this study. There are no consequences for not participating in this study. Any risks associated with this research do not exceed those of daily living. The survey should take about 15 minutes to complete. For further information regarding this research, please contact Drs. Cox and Wilhite at (216) 687-3808, email: v.cox@csuohio.edu or m.wilhite@csuohio.edu. I understand that if I have any questions about my rights as a research subject, I can contact the Cleveland State University Institutional Review Board at (216) 687-3630. Thank you in advance for your cooperation and support. Please answer the following question below by selecting yes or no in the box below.

I am at least 18 years old and am an audiologist or hearing aid specialist, I understand the information and want to take part in this study. If the answer is "yes", please proceed to question two.

☐ Yes (1)

☐ No (2)

Q2 I have been practicing in the field for less than a year.

- ○ Strongly agree (1)
- ○ Agree (2)
- ○ Somewhat agree (3)
- ○ Neither agree nor disagree (4)
- ○ Somewhat disagree (5)
- ○ Disagree (6)
- ○ Strongly disagree (7)

Q3 I have been practicing in the field for 1-3 years.

- ○ Strongly agree (1)
- ○ Agree (2)
- ○ Somewhat agree (3)
- ○ Neither agree nor disagree (4)
- ○ Somewhat disagree (5)
- ○ Disagree (6)
- ○ Strongly disagree (7)

Q4 I have been practicing in the field for 5-7 years.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q5 I have been practicing in the field for 7-10 years.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q6 I have been practicing in the field for 10-15 years.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q7 I have been practicing in the field for 15 or more years.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q8 I work in a private practice setting.

- Strongly agree (1)
- Agree (2)
- Somewhat agree (3)
- Neither agree nor disagree (4)
- Somewhat disagree (5)
- Disagree (6)
- Strongly disagree (7)

Q9 I work in a hospital setting.

- Strongly agree (1)
- Agree (2)
- Somewhat agree (3)
- Neither agree nor disagree (4)
- Somewhat disagree (5)
- Disagree (6)
- Strongly disagree (7)

Q10 I work in a hearing aid clinic.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q11 My job title is an audiologist.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q12 My job title is a hearing instrument specialist.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q13 There is a relationship between dementia and hearing loss.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q14 When using pure tone audiometry, I re-test patients that have fair or poor test reliability.

- Strongly agree (1)
- Agree (2)
- Somewhat agree (3)
- Neither agree nor disagree (4)
- Somewhat disagree (5)
- Disagree (6)
- Strongly disagree (7)

Q15 For patients 65 and older, if there is no response for a certain decibel frequency, I wait for a longer period of time before increasing the decibel level by 5dB.

- Strongly agree (1)
- Agree (2)
- Somewhat agree (3)
- Neither agree nor disagree (4)
- Somewhat disagree (5)
- Disagree (6)
- Strongly disagree (7)

Q16 For patients 65 and older, I wait 3 seconds before increasing the decibel level by 5.

- ○ Strongly agree (1)
- ○ Agree (2)
- ○ Somewhat agree (3)
- ○ Neither agree nor disagree (4)
- ○ Somewhat disagree (5)
- ○ Disagree (6)
- ○ Strongly disagree (7)

Q17 For patients 65 and older, I wait 5 seconds before increasing the decibel level by 5.

- ○ Strongly agree (1)
- ○ Agree (2)
- ○ Somewhat agree (3)
- ○ Neither agree nor disagree (4)
- ○ Somewhat disagree (5)
- ○ Disagree (6)
- ○ Strongly disagree (7)

Q18 For patients 65 and older, I wait 7 seconds before increasing the decibel level by 5.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q19 For patients 65 and older, I wait 10 seconds before increasing the decibel level by 5.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q20 For patients 65 and older, I wait more than 10 seconds before increasing the decibel level by 5.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q21 Hypothetical situation: A patient who has not had their hearing tested in over a year comes in and requests that you increase the gain on their hearing aids. You increase the gain based on the old audiogram.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q22 Hypothetical situation: A patient who has not had their hearing tested in over a year comes in and requests that you increase the gain on their hearing aids. You re-test the patient's hearing and increase the gain based on the new hearing test.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q23 Using pure tone audiometry is one of the best ways to obtain accurate threshold measures in patients 65 and up with poor test reliability.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q24 Using pure tone audiometry is one of the best ways to obtain threshold results in children ages 4-5 with poor test reliability.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q25 I recommend electrophysiological testing to patients that are 65 or older that have less than good test reliability.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q26 I recommend electrophysiological testing to patients that are age 4 to 5 that have less than good test reliability.

- ○ Strongly agree (1)
- ○ Agree (2)
- ○ Somewhat agree (3)
- ○ Neither agree nor disagree (4)
- ○ Somewhat disagree (5)
- ○ Disagree (6)
- ○ Strongly disagree (7)

Q27 Hypothetical Question: A patient comes in complaining that their hearing aids are too loud, so you retest the patient's hearing. Retest results show that there has been no change in hearing across frequencies from the previous audiogram. You adjust the gain on the hearing aid based upon the patient's subjective most comfortable listening level (MCL).

- ○ Strongly agree (1)
- ○ Agree (2)
- ○ Somewhat agree (3)
- ○ Neither agree nor disagree (4)
- ○ Somewhat disagree (5)
- ○ Disagree (6)
- ○ Strongly disagree (7)

Q28 I typically provide a cognitive screening for clients over the age of 65.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q29 I have questioned the reliability of the patient's responses who were over the age of 65 and were demonstrating signs of cognitive decline.

- ◯ Strongly agree (1)
- ◯ Agree (2)
- ◯ Somewhat agree (3)
- ◯ Neither agree nor disagree (4)
- ◯ Somewhat disagree (5)
- ◯ Disagree (6)
- ◯ Strongly disagree (7)

Q30 Is there any additional information that you can provide related to audiometric testing for patients over the age of 65 who may have cognitive decline.