The Relationship Between Hearing and Cognitive Function in Older Adults: Differences in Perception

by

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A thesis presented to the Honors College of Middle Tennessee State University in partial fulfillment of the requirements for graduation from the University Honors College

Spring 2021

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Acknowledgments

I would like to thank my thesis advisor and professor, Dr. Rebecca Fischer, for everything. She has been such a strong presence in my academic life and has constantly pushed me to do things I did not think I could accomplish. She has given me multiple pep talks throughout this project and constantly reminded me that I am capable. I would also like to thank my assistant researcher, Janna Spada, who shares the same enthusiasm for audiology. I could not have done this project without her. Next, I would like to thank my family for believing in me and providing me with everything needed to succeed in life. I am thankful for the daily phone calls checking in and the love they give me. Finally, I would like to thank my boyfriend, Ethan Bugg, for sometimes forcing me to sit down and work on this project and for all the "study buddies" supplied. Without these loving people in my life, I would not be where I am today.

Abstract

Individuals are now living longer than ever, which has brought up a new concern of preserving their quality of life. The geriatric population faces many challenges as they age. One of the primary hardships faced is their loss of cognitive function. As individuals age, they slow down both physically and mentally. Recently, hearing loss has been considered a modifiable risk factor for dementia. This means that a hearing loss could increase the likelihood of one being diagnosed with a cognitive deficit. The purpose of this study was to analyze if there was a relationship between hearing and cognitive function in 12 participants above the age of 65 years. This study also compared the subjective perceptions of the Primary Participant to their Communicative Partner. The results showed a significant correlation between the cognitive screener and the audiometric thresholds found in the lower frequencies. There was no correlation found between the different perceptions. These results agree with research done in the past and can be used to help the geriatric population as they age.

Preface

My first real job was working at an assisted living facility. I worked in the dining hall and had the pleasure of interacting with the residents daily. I credit this job with fueling my interest in the geriatric population. I witnessed firsthand some of their struggles and knew I wanted to assist them in any way possible. At the same time, my family noticed personality changes with my grandmother. She was becoming quiet and withdrawn. Finally, after a few visits to various health providers, she was diagnosed with moderate hearing loss and prescribed hearing aids. This personal experience provided me with the opportunity to observe how devastating a decline in hearing can be for an individual. I watched how my grandmother's life was completely altered by her hearing loss. She was not herself. However, with the guidance of an Audiologist and the correct fitting of hearing aids, she regained her confidence. She no longer feels isolated, and she can follow conversations with the family. These experiences have encouraged me to pursue my passion of becoming an Audiologist so I can help those who are facing the same struggles.

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The Relationship Between Hearing and Cognitive Function in Older Adults: Differences in Perception

The world's population has evolved from years past, and people are living longer than ever. Modern technologies have given humans the ability to gain the upper hand. While lifespan has lengthened, a new challenge has manifested: the quality of life for the older population. Quality of life derives from a range of different factors that make individuals' lives more difficult or easier. One example is hearing loss. As one increases in age, hair cells in the cochlea diminish due to the years of use, a disorder called presbycusis. Once one reaches a certain age, "for every 5 years, the risk of hearing loss increases by almost 90%" (Cruickshanks, et al., 1998, p. 881). This is an epidemic factor from which one cannot escape since people simply use their ears every day of their lives. This constant use weakens the auditory system. "Hearing loss affects nearly two-thirds of U.S. individuals of ages 70 years and older" (Lin, et al., 2011). This fact supports the idea that researchers must work towards finding techniques to slow the process of hearing deterioration or aid individuals with hearing loss.

While hearing loss can lead to isolation and depression, it can also lead to a gradual cognitive decline. There are, "many cross-sectional or longitudinal cohort studies that have documented hearing loss is associated with cognitive decline or dementia" (Park, et al., 2016, p. 1). Finding the relationship between the two factors is crucial in discovering a way to halt hearing loss and restore quality to the lives of individuals facing the inevitable task of aging.

Hearing

It is important to understand the anatomy of the ear when discussing anything hearing-related. Ears are unique to each individual, meaning everyone can hear different levels or pitches. This has everything to do with anatomy. The outer ear, or pinna, is the basic structured ear that is visible to all. Many are unaware that the size, shape, and orientation of the pinna impacts the individual greatly. The concaved shape of the ear allows sound frequencies to become trapped and amplified before entering the ear canal. "The bowl-shaped concha increases sound levels by up to 10 to 15 decibels in the frequency region of 4500Hz" (Hall, 2014, p.56). Localizing sound is very important in one's day-to-day life. The placement and arched forwardness of the pinna allows the sound coming to the listener to become amplified, while the sounds behind the listener are not as loud.

The ear canal is an S-shaped tube that travels from the pinna to the tympanic membrane, or eardrum. The shape of the ear canal helps protect the sensitive and important tympanic membrane. Cerumen, or ear wax, is another way the body helps to protect the tympanic membrane. The canal is made of bone and cartilage, and the average length in adults is about 2.5 cm. Again, this structure helps to amplify sounds for the listener. The resonant frequency range of 2500 to 5000 Hz is important in the distinction of consonants and aids the listener.

The middle ear begins on the medial side of the tympanic membrane. The middle ear cavity is air-filled and has a volume of about 2 cm^3. It consists of the ossicle bones, nerves, muscles, the eustachian tube, and windows into the inner ear. These are all fragile and sensitive structures, but the cavity is surrounded by one of the strongest bones in the

head- the temporal bone. The most important structures found in this cavity are the ossicle bones and the eustachian tube.

The ossicle bones are made up of three small bones that are all connected and travel from the tympanic membrane to the inner ear. The first bone is the malleus. This bone is sometimes visible when looking at an individual's tympanic membrane due to it resting against the inner portion of the membrane. The head of the malleus connects to the incus bone. The incus bone then connects the stapes bone. The stapes bone is the smallest of the three and the end of the chain. The footplate of the stapes inserts into the oval window, which is the entrance to the inner ear. It is important to have the smallest bone last to increase the vibration from sound energy to its heightened level. If it were not for this, "about 30 dB would be lost on the route from the external ear canal to the inner ear (Hall, 2014, p. 61)." Another important structure within the middle ear is the eustachian tube. This tube is used to ventilate and aerate the middle ear which helps ensure the pressure is equalized. The tube extends from the middle ear to the throat or pharynx and consists of bone and cartilage.

Finally, a description of the inner ear. The entrance to the inner ear is the oval window where the footplate of the stapes bone inserts. This section of the ear is the most important and complicated when it comes to hearing. Within the fluid-filled inner ear, there is the cochlea and the vestibular system. The vestibular system's function is primarily focused on balance, while the cochlea is the primary system for hearing. One nickname given the cochlea is "labyrinth," meaning "maze." This name holds true due to its structure: tube-shaped and separated into three sections by thin membranes, this tube is then wrapped around another structure several times. The three sections are the Scala

Vestibuli, Scala Media, and then the Scala Tympani. Within this tube-shaped structure is the Organ of Corti.

The Organ of Corti is a highly complex structure found within the Scala Media section of the cochlea. For the purpose of this paper, only the components that are most involved with processing sound will be discussed. The three important components of the Organ of Corti would be the Tectorial Membrane, the Basilar Membrane, and the Hair Cells. The two membranes create the top and bottom of the Organ of Corti, with the Tectorial Membrane being the top and the Basilar Membrane being the bottom. Within the membranes, lies both Outer and Inner hair cells. These Hair Cells are connected to the membranes, so when the membranes move, the hair cells move as well. One way to think of the movement is a scrunch. When the hair cells scrunch, signals are fired to the brain through afferent and efferent nerve pathways.

Brains are unable to process soundwaves that enter the ear, so the ear must work as an energy transducer. This means once the sound reaches the ear drum, it is already working to transduce the energy into signals the brain can decipher, which is electrical energy. The process is as follows: soundwaves enter the ear canal; when the soundwaves hit the ear drum, they are transformed into mechanical energy where it stays this form until it reaches the inner and outer hair cells, where it is then turned into electrical energy for the brain.

This information is vital when learning and understanding hearing loss. There are three types of hearing loss: conductive, sensorineural, and mixed. A conductive loss occurs when the lesion is found at the beginning of the hearing cycle, so either in the outer or middle ear section. A sensorineural loss occurs when the pathology is within the

inner ear, while a mixed loss is a combination of both. In most cases, older patients experience a sensorineural or mixed hearing loss (Hall, 2014).

As one ages, both inner and outer hair cells found in the inner ear can deteriorate. This is classified as presbycusis, or age-related hearing loss. It is "characterized by gradually developing high-frequency loss, often accompanied by poor speech discrimination" (Slade, et al., 2020, p.810). This sensorineural hearing loss is extremely common, and the probability of loss increases with age. For people 70 years or older, the probability of age-related hearing loss rises to around 70% (Slade, et al., 2020). Presbycusis is "an exclusion diagnosis" (Yurtogullari, 2020, p. 76). This means one is diagnosed with presbycusis once all other possible etiologies have been ruled out. One of the main causes of presbycusis arises from the constant use of ears and exposure to frequent and loud noises. This is something one cannot avoid -- there are simply noises in everyday life. Sadly, there is currently no way to regrow or replace the deteriorated hair cells. Instead, it is crucial to aid this loss as soon as one knows about it.

Hearing loss has been deemed a "primary contributor to the global burden of chronic disability in the United States" (Stika & Hays, 2016, p 381). A hearing disability, no matter the level, causes many negative effects and can dramatically lower the quality of life for an individual. One of the primary hardships of hearing loss is simply the struggle to hear what friends and family are saying. Constantly asking for clarification on what is said can get tiring, causing many to struggle in silence and lose interest in the conversation. Noisy environments, such as a restaurant or a party, are even more difficult for these individuals. This results in isolation. The fear and annoyance of

being unable to hear become too much, and people with hearing losses would rather stay in the comfort of their homes.

Many studies have looked at the quality of life in the elderly population experiencing hearing loss. They "have found that the untreated elderly with hearing loss often suffer feelings of sadness, anxiety, depression, insecurity, and social isolation, all of which are lessened through cochlear implants or hearing aids" (Boi et al, 2012, p. 441). It has been observed that with the help of hearing aids, individuals can feel happier and improve their quality of life.

In a study conducted by Boi et al, the improvements in mood and quality of life using aids were assessed. A total of 15 participants who were experiencing hearing loss along with the negative effects, depressive mood, and all-around low quality of life, were recruited. Surveys were used to analyze their quality of life and included: *The Cumulative Illness Rating Scale*, the *Activities of Daily Life scale*, the *Lawton Instrumental Activities of Daily Living scale, Mini-mental State Examination*, the *Clock Drawing Test*, the *Center for Epidemiological Studies- Depression Scale*, and the *Short-Form Health Survey*. These scales evaluated the participant's functional ability, cognitive capacity, psychological states, and quality of life. Participants completed these assessments at 1-month, 3-month, and 6-month intervals. The scores for all the assessments improved significantly once the participants were aided with hearing instruments. Results of this study demonstrate how crucial and beneficial it is to seek help from an audiologist when there is a suspected hearing loss. It is also important to note the current participants were tested for comorbid factors prior to beginning the study, and none were found. Results

might have had a different outcome if comorbidity was observed, so it is even more crucial to find help as soon as a loss is noted.

A hearing loss can also negatively affect the individual's brain. The ear and brain are connected and work simultaneously to provide hearing and understanding. The ear is a gateway that gives the soundwave an entrance to the brain, and the brain then processes the energy to comprehend what was heard. The region of the brain that focuses on hearing is the auditory cortex found within the temporal lobe. Studies have observed alterations and atrophy to the auditory cortex's structure and function found in those with an age-related hearing loss. Some examples of these changes are decreased Gamma-aminobutyric acid (GABA) levels and a reduced amount of gray matter volume in the auditory cortex area (Gao et al., 2015). There have been many studies conducted that show how a hearing loss can impact the brain (Eckert et al., 2012; Eckert et al., 2019; Rigters et al., 2017;).

The direct causal relationship suggests the brain becomes affected and is altered due to hearing loss. The lack of stimulation that reaches the inner ear, and then the brain, is the cause of the brain's transformation, sometimes referred to as the auditory deprivation hypothesis.

A longitudinal study conducted by Lin et al., (2014) looked at brain atrophy in both participants with hearing loss and those with typical hearing. To do this, researchers gathered a baseline of brain volume in both sets of participants. After around 6 years, brain volume information was gathered a second time. The findings suggested those with a hearing decline had a higher rate of atrophy in the brain versus those without decline. The volume decline was found in the whole brain, as well as within regional areas in the

right temporal lobe. This study supports a direct causal relationship between hearing and the brain. It is still unknown why exactly there is a loss of volume, but it could be due to lack of stimulation.

Another study supporting a direct causal relationship was conducted by Gao et al. (2015). It looked at GABA levels in both participants with presbycusis (sixteen participants) and typical hearing (twenty participants). GABA is a neurotransmitter naturally found in one's brain that acts as a messenger (*healthline.com*). To find this, participants were examined using *Magnetic Resonance Spectroscopy* and administered a hearing evaluation. The results showed that GABA levels were significantly lower in the group of presbycusis participants compared to the control group (Gao et al., 2015), supporting a causal relationship. The lower level of GABA correlating to presbycusis also alludes to a possible new way of treatment for clients with presbycusis. However, it is important to note that the majority of the older population experiences a decline in GABA levels (Lalwani et al, 2019).

An age-related hearing loss can negatively impact one's life in many different aspects. These occur in a hierarchy format, beginning with noticing a hearing loss; then to it impacting one's social and emotional life; and finally, with it altering the brain. However, with the use of hearing aids or other forms of amplification, the impact of hearing loss might not be so detrimental. It is crucial to find this amplification swiftly before its negative effects impend too heavily on the individual. Another reason for quick amplification is the possibility that a hearing decline can alter one's cognitive ability (Lin et al., 2013; Sarant, et al., 2020; Tognoloa, et al., 2019).

Cognition

MyungJin Huh (2017) explained that cognitive decline can cause an individual to lose the ability to process diverse types of information, damaging intelligibility and limiting the function of everyday activities an individual can perform independently. Social isolation and depression are common factors of hearing loss, but they are also quite common in persons with cognitive loss as well (Fulton, et al., 2015). A prime example of cognitive loss is shown in dementia and in Alzheimer's disease. As people age, they start to slow down mentally and physically. Some cognitive skills that are lost include short-term memory, listening abilities, and lack of ability to hold new information. All are skills needed to live an independent lifestyle.

Although there are ways to assist individuals in need, it is important to stop the cognitive decline process prior to it significantly impacting a person's life. "The prevalence of dementia is projected to double every 20 years" (Lin, et al., 2013, p. 293). By the year 2050, the number of individuals diagnosed with dementia is projected to reach over 131 million (Prince, et al., 2015). These statistics are most likely so high due to the fact people are living longer. Since people are living much longer, a new problem related to the quality of life has revealed itself. Quality of life is primarily subjective (Weyerer & Schaufele, 2003). One of the most notable and common outcomes of patients experiencing a cognitive decline is depression (Jungel, et al., 2020) Depression can greatly impact one's quality of life. Symptoms include "loss of appetite, sleep disturbances, loss of energy, involvement, and pleasure (Balsamo, et al., 2018)." Late-life

depression and cognitive decline are often coupled and similar in their symptoms, which can make the differential diagnosis challenging" (Liguori, et al., 2018).

To increase individuals' quality of life, it is crucial to find ways to lower prevalence. First, the cause of dementia must be found. Two-thirds of diagnosed dementia is genetic (Livingston, et al., 2017). However, "it is estimated that over one-third of dementia cases may be preventable through lifestyle measures such as improved education, reduced smoking and the management of hearing loss, diabetes, and obesity" (Sarant, et al., 2020, p. 2). These are lifestyle changes that must be implemented at an early age to be successful in stopping dementia. However, all are habit-forming and difficult to break, so understanding the harm these lifestyles have at an early age is key. There have been studies looking at psychological risk factors, such as personality traits and the state in which individuals live. Both self-disciplined and shy personality traits found no relationship with Alzheimer's dementia (Wilson, et al., 2007; Wilson, et al., 2011). Depressive symptoms have been shown to negatively impact cognition (Wilson, et al., 2014). However, having a strong sense of purpose in life was shown to have a negative correlation with Alzheimer's dementia and cognition (Boyle, et al., 2012). Meaning a strong sense of purpose decreased one's risk of a cognitive deficit.

Ways to possibly prevent the onset of dementia, or other cognitive declines, include being informed about a family history of dementia; having a higher education; performing physical, cognitive, and socially stimulating activities; eating a healthy diet; and sleeping enough (James & Bennett, 2019). Hearing loss being a risk factor for dementia is a newer idea, but there has been significant research regarding this topic. Hearing loss is estimated to account for up to 9.1% of the modifiable risk factors

(Livingston, et al., 2017). Researchers are interested in this modifiable risk factor due to the ability to lessen the impact hearing loss has on individuals. There have been multiple studies conducted looking at the relationship between hearing and cognition (Lin et al., 2013; Tognoloa et al., 2019; Livingston et al., 2017).

A prospective study conducted in 2013 by Lin and colleagues looked at the relationship between hearing and cognitive decline. This study observed close to 2,000 participants for six years to find the possible trajectories of hearing or cognitive decline. Participants were between the ages 70-79 years and were all well-functioning for their age. At baseline, participants showed no signs of cognitive impairment. Cognition was tested using the *Modified Mini-Mental State Examination (3MS),* which measures orientation, concentration, language, praxis, and memory; and the *Digit Symbol Substitution,* which measures the psychomotor speed and executive function (Lin et al., 2013). All are key components in determining if a decline is present. Hearing assessments were completed in year 5 in a soundproof room. Air conduction thresholds were found in both ears from 250 to 8000 Hz with headphones. A hearing loss was labeled as a pure tone average exceeding 25 decibels. This study also looked at other possible covariates that could impact results such as, age, sex, ethnicity, and education. From these covariates, it was found that one was more likely to have a hearing loss if the participant was a male, older, white, and had a history of smoking as compared to persons with normal hearing. When looking at cognitive assessments, those who scored lower on the *3MS* test were also more likely to have hearing loss. “On average, individuals with hearing loss had cognitive scores at baseline that were -0.75 points lower on the *3MS* and -0.92 points lower on *the DSS* test than individuals with normal hearing (Lin et al., 2013,

p 294). This finding supports the idea that those with a cognitive decline are at a higher risk for hearing loss, meaning it is vital to catch these individuals early and aid them so further decline does not continue. Lin et al (2013) demonstrated that further decline for individuals whose scores were lower at baseline did occur. Participants who scored low on *3MS* and had a hearing loss showed an annual hearing decline that was 41% greater than those with normal hearing. With the *DSS* test, those with a hearing loss declined at a rate that was 32% greater than those with normal hearing.

Lin et al. (2013) investigated the use of hearing aids to end cognitive decline. 182 of participants were aided. These participants had a higher baseline cognitive score on the *3MS* but not on the *DSS* test. The study suggested there was not a significant difference within the trajectories of the decline of cognition in those with hearing aids versus those without. However, the only levels of loss used were moderate or greater losses, so it is possible that to stop the greater decline one must become aided at an earlier stage of their loss. This suggests that time plays a vital role in slowing the process of cognitive decline (Lin, et al., 2013).

"Hearing loss is the highest modifiable midlife risk factor for dementia in later life" (Livingston, et al., 2017, p. 2675). This statement suggests that while there are many factors that could possibly correlate with cognitive decline, an improvement in hearing can potentially lower that risk. Hearing aids are particularly useful and effective tools when it comes to hearing loss. While they do not bring individuals back to typical hearing, they do assist individuals in better understanding conversations. This allows for more socialization with peers and less isolation. Prevention of cognitive loss is far more time-efficient than the delayed treatment of cognition loss.

Another study conducted in 2019 by Tognoloa and colleagues looked at the benefits of hearing aids and how they affect the participants' age, cognition, and hearing. A total of 102 participants who had been wearing hearing aids for over a year were observed and assessed. The assessment showed significant audiometric improvement, as well as a reduced feeling of handicap from their hearing. Once again, it was noted that "better aided audiometric outcomes were significantly associated with hearing impairment of a lower degree and higher cognitive abilities" (Togoloa, et al., 2019, p. 409). This finding reiterates the importance of hearing aid use at an earlier rather than later time.

Another study by Sarant et al. (2020) looked at how hearing aids impacted cognitive decline. The purpose of this study was to see how hearing aids influenced cognition as well as physical health, social isolation, loneliness, mood, exercise, quality of life, and sex. These areas can also impact cognition. Sarant and colleagues examined 99 adults between the ages of 60 and 84 years who had no presumed cognitive decline. Participants were assessed before their hearing aid fitting for a baseline evaluation, as well as 18 months after hearing aids were fitted. Baseline data consisted of an audiometric assessment, speech perception, cognitive screening and cognitive assessment, and questionnaires measuring health, quality of life, lifestyle, and ease of listening.

The results of the baseline questionnaires found that within the participants, 17.3% had anxiety, 4.1% were depressed, 43.9% reported loneliness, and 57.1% performed high levels of physical activity. The average score for quality of life, found through the *Health Utilities Index-3* (*HUI3*), was 0.74 out of a maximum score of 1.

According to the *HUI3* questionnaires, 61.2% of participants felt they had no hearing loss, 7.1% believed they had mild hearing loss, 26.5% believed they had a moderate hearing impairment, and 5.1% felt they had a severe loss. The audiometric assessment revealed a 36 dBHL pure tone average for the better ear. To measure cognitive function, this study looked at executive function; psychomotor function; working memory; visual attention; visual learning; and the *Mini Mental State Examination* (*MMSE*). The scores at baseline for each of these cognitive functions were as follows: executive function- 56.73; psychomotor function- 2.59; working memory- 2.96; visual attention- 2.78; visual learning- 0.97; and *MMSE*- 28.73.

The next part of this study consisted of a second assessment 18 months after the participant's hearing aid fitting. Only 37 of the 99 participants followed up with this assessment. Participants were asked about their adaptiveness to the hearing aids, and researchers found that 35.3% felt adapted to their hearing aids within one week. Speech perception scores increased significantly from 85.46% at baseline to 93.7% at 18 months. The results showed a significant improvement in executive function going from a raw score of 58.8 to 51 (that is, lower scores represented better executive function), with a total of 29.7% of participants improving. The other areas of cognition measured either stayed the same or did not improve by a significant amount. Due to the decrease in participants, it was impossible to create a formal statistical inference. However, "two participants were anxious at baseline but were not at 18 months, one was depressed but was not at 18 months, and four participants were severely lonely at baseline but not at 18 months. One participant was severely lonely at 18 months but was not at baseline" (Sarant, et al., 2020, p. 15). The *HUI3*, an evaluation of quality of life, had a clinically

significant increase of .08. The hearing disability scale within the *HUI3* had 19 participants report an increase in their hearing disability and 10 participants reported a decrease in their hearing disability.

The results of this study showed that hearing aids are beneficial in assisting individuals with their speech perception, which is very important in understanding and communicating with peers. Increasing one's speech perception has the chance to reduce the negative psychological effects a hearing loss has on individuals. Sarant et al. (2020) supports this possibility by reporting an increase in the quality of life using hearing aids. This study also looked at the relationship between hearing aids and cognitive function, but there was no significant improvement. However, there was a significant improvement in executive functions, which is the ability to make plans and follow through with them. One of the possible reasons for this is the high level of education of the participants in this study. Another possibility is the decrease in participants for the second assessment. Further investigation on this topic is needed to better understand the positive influence hearing aids have on individuals.

All these previously discussed studies have examined the possible relationship between hearing and cognitive function. Understanding the reasoning behind the relationship is unknown, but there have been several hypotheses suggested to explain the relationship (Fulton et al., 2015). The cognitive load hypothesis suggests that there is more mental effort exerted when an individual with hearing loss tries to listen and comprehend conversation, causing less effort to go toward the individual's cognitive performance. Another term for cognitive load is cognitive distraction (Engström, et al., 2017). This term helps to understand the concept of mind wandering when the individual

finds himself or herself self not paying attention to their communicative partner, for example. The cascade hypothesis explains that cognitive decline comes from the limited use of the auditory system due to hearing loss. It is natural that when one cannot connect with others as easily as beforehand due to a hearing decline, the individual will isolate themselves. Social isolation then causes a lack of interacting and communicating with others as frequently as before, limiting the use of their auditory system and mental abilities (Dawes, et al., 2015). The common cause hypothesis simply states that both hearing loss and cognitive decline occur due to age-related causes. As one ages, their nervous system changes, which in turn causes a decline in many areas. These areas can range from heart function, vision, hearing, and many more. Age is simply a factor that one cannot avoid (Baltes & Lindenberger, 1997). These hypotheses allow further investigations to take place in hopes of limiting it down to one final cause (Dawes et al., 2015).

Word Recognition

Word recognition, or speech perception, is the ability to understand speech. Both auditory and cognitive skills are needed to process words and communicate (Martin, et al., 2005). Justifiably, a hearing loss hinders one's ability to fully hear and therefore comprehend what word has been said. This is especially true in the older population with presbycusis (Humes & Roberts, 1990). A characteristic of presbycusis is a big drop of thresholds in the higher frequencies. A speech banana, or an audiogram with frequencies of common speech sounds, shows how impactful this loss can be for individuals' ability of hearing certain speech sounds (Clergy, 2020). The inability to hear certain speech sounds negatively impacts word recognition. Another struggle found with word

recognition is the listening environment. It is especially difficult to comprehend speech in noisy areas, such as a restaurant. Background noise can be classified as anything that prohibits full attention to the signal, or speech. Much of the elderly population report they are aware of speech in loud background noises, but cannot comprehend the words spoken (Martin, et al., 2005). A loud background noise is very disturbing and can impede on one's concentration and communication (Manan et al., 2016).

While younger individuals with no hearing loss can effortlessly hear in noisy environments, the older population must exert more energy and focus harder. This is due to their cognitive processing skills (Martin, et al., 2005). Two studies by Cabeza and Cabeza et al. in 2002, noted that changes in the cognitive areas of attention and memory disrupted the individual's speech understanding in noisy environments. Difficulty in these areas, as well as other age-related declines, can later contribute to further decline of cognitive skills, such as executive function (Manan et al., 2016). Attention is needed to focus on the stimulus presented instead of background noises. With competing stimuli, it can be challenging for the individual to remain focused and interested in the conversation. Memory is needed to help the individual take in the stimulus and remember it long enough to form a reply. These are both important to holding a conversation. The lack of these skills can result in social isolation due to the limit of conversation skills.

Communication Partner

Many times, individuals with hearing loss do not even realize their hearing has declined until someone close to them recognizes it. While in a close relationship, this can be a perplexing task. "The impact of hearing loss can have collateral psychosocial effects on communication partners, which have been defined as spouses, partners, close family

members, or caregivers" (Barker, et al., 2017, p. 297). Experiencing a close partner decline in hearing is challenging and can be difficult to assist. While it is hard to witness this decline firsthand, it is even more difficult for the individuals themselves to understand and process what is occurring to their bodies. Coping with hearing loss can sometimes leave one distraught, causing the individual to ignore the fact that one might not be hearing as well as typical listeners, a process referred to as disengaged coping. A more effective strategy is engaged coping, which is when the communication partner shows interest in aiding and comforting the individual with a hearing loss. When partners are more engaged in their coping and reassurance, it gives confidence to the individual living with this loss. However, some individuals do not understand this importance, which brings strain to the person with hearing loss as well as to the partner and to the relationship.

Family involvement during appointments is very beneficial by allowing emotional support, giving detailed information for the audiologist, and retaining the information given. Family support also has a chance to increase the patient's hearing aid satisfaction (Singh, et al., 2015). A recent study's purpose was to learn about adult patients' hearing experiences and perspective of their family's involvement (Reynolds, et al., 2019). Participants answered four different surveys centered on demographics, general hearing, hearing experiences, and family interactions and involvement. Of the 382 adult participants, 40% stated they would not want family members to attend future audiologist appointments. These patients felt it was not necessary to have family attend. Of the participants who said they wanted family attendance, the primary answer was for

educational and supportive reasons. There was a mixed outcome for family involvement in this study, but many participants understood the benefits.

This leads into a discussion into the differences of perception between the primary participant and their communicative partner. While it is known that the patient would answer questionnaires on their hearing most accurately, someone who is constantly around the individual could answer as well. Due to the loss in function the individual is experiencing, the individual might not fully comprehend or notice how the loss is impacting them. Many times, communicative partners correct patients on their answers regarding the state of their hearing, and explain the patient is overestimating his/her level of function. Though it is important to listen to the patient, using this form of additional information helps to see the full picture of the situation. (Mistry, et al., 2014).

Both hearing and cognitive loss have been found to negatively impact the individual and their communicative partner. Separately, these two functions have been researched for many years. Research on the association of these two functions is necessary to improve the quality of life for the human population, which is increasing in age. Finding ways to decrease the prevalence of dementia would greatly benefit those in need. Hearing loss is modifiable with the use of hearing aids or other assistive devices. The discovery of whether assistive listening devices can alter the trajectory or possibly halt the onset of dementia could change the way individuals age and place a higher importance on audiology.

Purpose

The purpose of this study is to compare the results collected from an audiometric evaluation; cognitive screening; and surveys filled out by both the subject and the

subject's communicative partner. Comparing these data points will show how the subject and their partner experience and process a decline in hearing and possibly, decline in cognitive function. In some cases, many individuals feel as if they have no decline, but their significant other would say otherwise. Through this research, further insights may be revealed about whether hearing loss leads to a cognitive decline. An in depth look on how communication partners' reactions or thoughts on the decline will also be examined. The questions posed include:

1. Is there a difference in the subjective perception of hearing handicap between the Primary Participant (person with potential hearing impairment) and their Communicative Partner?
2. Is there a difference in the subjective perception of cognitive status between the Primary Participant and their Communicative Partner?
3. Is there a relationship between the objective assessments of hearing and the subjective perceptions of hearing?
4. Is there a relationship between the objective assessments of cognitive function and the subjective perceptions of cognitive status?
5. Is there a relationship between the objective cognitive screening results and objective hearing evaluation results?

Method

Participants

The current research study was approved by the Institutional Review Board at Middle Tennessee State University (See Appendix A.) The original plan of recruiting

participants from local retirement homes changed due to the pandemic. Instead, participants were recruited using word of mouth. Family members and friends of Middle Tennessee State University's (MTSU) faculty and students were asked to participate (See Appendix A.) There was a total of 12 dyads, each consisting of a Primary Participant and their Communicative Partner. Primary Participants were 65 years or older, may or may not have had a hearing loss, and had a Communicative Partner. A Communicative Partner was classified as an individual who remained in constant communication with the Primary Participant, for example, a spouse, child, friend, etc. (See Table 1 for demographic information.) Once participants were contacted, they were given information about the study and consent forms (See Appendix A); a client history form (See Appendix B), and scheduled for an evaluation at MTSU's Speech-Language-Hearing Clinic during the month of March 2021,

Materials

Two questionnaires for both the Primary Participant and Communicative Partner targeted their subjective perception of hearing and cognitive function. The questionnaires given were modified versions of the *Hearing Handicap Inventory for the Elderly Screening Version (HHIE-S)* and the *Symptoms of Early Dementia- 11 Questionnaire (SED-11Q)* (See Appendix C).

The *HHIE-S* is a five minute, 10-item questionnaire that investigates how an individual perceives the social and emotional effects of hearing loss. This version of the *HHIE-S* was created in 1983. The individual answers questions asked with either: 'yes,' 'sometimes,' or 'no.' Each answer is worth a certain number of points: 'yes' being worth 4 points, 'sometimes' worth 2 points, and 'no' worth 0 points. Once the questionnaire is

completed, the investigator tallies up the total number of points to discover their perception of the effects from hearing loss. The higher the score, the more likely it is that the individual has a hearing impairment. This screening has been used by multiple researchers and audiologists since the early 1980's. A cross-sectional study by Serdoni and Conterno (2018), looked to see the accuracy of this screening when compared to finding the Pure Tone Average threshold of the same individual. The study "found high values in the *HHIE-S* accuracy, sensitive, specificity, and positive value, whereas only the negative predictive value showed a lower percentage (Seridoni & Conterno, 2018, p.7)."

The *SED-11Q* was created in 2013 by researchers in Japan. It is an 11-item questionnaire that can be administered in about 5 minutes. The authors created this questionnaire to help assist caregivers identify dementia early in their patients and to do so in a timely manner. Two well-known batteries they pulled from were the *Mini Mental State Examination (MMSE)* and the *Clinical Dementia Rating (CDR).* The *MMSE* was considered to be too time-consuming as well as insensitive to detecting early stages of dementia (Lawrence et al, 2001). The *CDR* was not considered a screening tool and needed to be conducted by a trained practitioner (Morris et al, 2018). The SED-11Q was perfect for use in this study due to the simplicity, time, and questions asked. The target categories for this questionnaire were memory deficits, difficulties with the activities of daily life, and changes in social interaction and personality. The investigator scores the questionnaire the same way as the *HHIE-S*, by tallying up the total of points given by the answers. However, with this questionnaire, there are only two options: yes or no. 'Yes' is worth one point and 'No' is worth zero points.

These questionnaires were altered to fit the Primary Participant and Communication Partner. For further reference, the questionnaires targeting the Primary Participant will be referred to as *HHIES-PP* and *SED-11Q-PP,* and the questionnaires targeting the Communicative Partner will be referred to as *HHIES-CP* and *SED-11Q-CP*. The only alteration for these questionnaires is found in the individual (Primary Partner or Communication Partner) to whom the questions were addressed. For both *HHIES-PP* and *SED-11Q-PP*, the questions were asked in first-person and addressed to the Primary Participant. For both *HHIES-CP* and *SED-11Q-CP*, the questions were asked in third person and addressed to the Communication Partner. An example from *HHIES-PP: Does a hearing problem cause **you** to feel embarrassed when meeting new people?* While an example from *HHIES-CP: Does a hearing problem make **your partner** feel embarrassed when meeting new people?*

Procedure

The Primary Participant and Communicative Partner were given the questionnaires in two separate rooms to ensure there was no communication between the two. They were informed that the results of these questionnaires would not be shared to guarantee the two gave their honest opinions.

Once the questionnaires were completed, the Primary Participant began the formal hearing evaluation. The primary investigator and assistant investigator were trained by a licensed audiologist to perform otoscopic viewing; tympanometry measurements; pure tone thresholds air conductions; pure tone threshold bone conductions; masking; and word recognition testing. All of these were performed during the formal hearing evaluation. Pure tone thresholds were obtained at 250, 500, 1000,

2000, 4000, and 8000 Hz. The investigator calculated the *Low Frequency Pure Tone Average (LPTA)* and the *High Frequency Pure Tone Average (HPTA)*. *LPTA* was found by computing the average of threshold 250, 500, and 1000 Hz. *HPTA* was found by computing the average of threshold 2000, 4000, and 8000 Hz.

The order in which the data was collected at is as follows: otoscopic viewing; tympanometry measurement; pure tone air conduction; word recognition threshold; and then pure tone bone conduction and masking if needed. Once this was completed, the primary and assistant investigator discussed the results with both the Primary Participant and Communicative Partner. A hearing threshold is the quietist tone one can hear, so a low hearing threshold means the individual has better hearing and a high threshold means the individual has poorer hearing.

Word recognition scores for both the left ear and right ear were obtained. Participants were instructed to listen to the male speaker and repeat the words he stated. The words were presented to the test ear at 80dBHL with babble noise presented to the non-test ear at 55dBHL. One could compare babble noise to the noise found in a loud restaurant.

Word recognition was also conducted in the sound field through speakers located in the sound booth. The list consisted of 25 prerecorded words (See Appendix D). For the sound field portion, the Primary Participants were seated facing one speaker with a second speaker located directly behind them. The word list was presented at 60 dBHL from the speaker in front of the Primary Participant, while the babble noise was presented at 52 dBHL from the speaker behind the Primary Participant. This was meant to mirror a noisy restaurant and difficult listening situation. The investigators tallied the number of

correct responses compared to the total of 25 words to find the percent correct for each condition.

The last step in the research process was the cognitive screening. *The Montreal Cognitive Assessment (MoCA)* was used (See Appendix E). The primary investigator completed training and was certified to complete this screening. The screening tool tested the following: attention; concentration; executive functions (memory, conceptual thinking, calculation, language); orientation; and visual constructional skills. The screening took 10 minutes to perform. Once the screening was completed, the primary investigator calculated the score and discussed the results with the Primary Participant and their Communicative Partner. Calculation of the *MoCA* score was completed by tallying the correct answers given. Participants were also granted an additional one point if they had 12 or less years of education. There was a possible 30 points the individual could score. According to the *MoCA*, a score of 26 or greater was typical cognitive function. Primary Participants were given a list of local neurologists to be referred to if the primary investigator felt it was necessary.

The data collected was analyzed using paired t-tests and a Pearson correlation procedure.

Results

A table of raw scores is found in Table 2.

Difference in Subjective Perceptions of Hearing Handicap.

The subjective perceptions of hearing handicap by the Primary Participant (*HHIES-PP*) and their Communicative Partner (*HHIES-CP*) were evaluated using paired

comparison t-tests. The results, which can be viewed in Table 4, were not significant. That is, there was no difference in how the Primary Participant or their Communicative Partner perceived the hearing handicap of the Primary Participant as measured by the *Hearing Handicap Inventory for the Elderly-Screening Version.*

Difference in Subjective Perceptions of Cognitive Function.

The subjective perceptions of cognitive function by the Primary Participant (*SED-PP*) and their Communicative partner (*SED-CP*) were evaluated using paired comparison t-tests. The results were not significant and can be found in Table 4. The results indicate there was no difference in how the Primary Participant and their Communicative Partner perceived the cognitive function of the Primary Participant as measured by the *Symptoms of Early Dementia- 11 Questionnaire.*

The Relationship Between Objective Measures (LPTA, HPTA, and WRN) and Subjective Perceptions (HHIES-PP and HHIES-CP) of Hearing.

A Pearson Correlation was performed to evaluate possible relationships between variables studied in this research project. The results can be viewed in Table 5.

There was not a significant difference between the objective measures of hearing (*Low-Frequency Pure Tone Average, High-Frequency Pure Tone Average, and Word Recognition in Noise*) and the subjective perceptions of hearing as measured by the *Hearing Handicap Inventory for the Elderly Screening Version*-Primary Participant or the *Hearing Handicap Inventory for the Elderly Screening Version*-Communicative Partner.

The Relationship Between the Objective Measure (MoCA) and Subjective Perceptions (SED-PP and SED-CP) of Cognitive Function.

There was not a significant relationship between the *MoCA* and the subjective perceptions of cognitive function as measured by either the *Symptoms of Early Dementia*-Primary Participant or the *Symptoms of Early Dementia*-Communicative Partner.

The Relationship Between the Objective Cognitive Screening and the Objective Hearing Evaluation Results.

A significant negative correlation (-.621) was found for the relationship between the *MoCA* and the *Low-Frequency Pure Tone Average*. (p=.031). That is, as scores on the *MoCA* increased, the *Low-Frequency Pure Tone Average* was lower. The correlation value of -.621 is strong.

There was not a significant relationship between the *MoCA* and either the High-Frequency Pure Tone Average or the Word Recognition in Noise performance. While there were significant correlations between the Low-Frequency Pure Tone Average and the High-Frequency Pure Tone Average, and between the High-Frequency Pure Tone Average and the Word Recognition in Noise, these relationships were not the focus of the current study.

Significant correlations between the Symptoms of Early Dementia-Primary Participant and both the Low-Frequency Pure Tone Average and High-Frequency Pure Tone Average were also found. Again, these relationships were not examined in the current study.

Discussion

The purpose of the current study was to investigate the different perceptions, in both hearing and cognitive function, found between a Primary Participant and their Communicative Partner. The study also compared the subjected perceptions to the objective assessments to see if there was any correlation between the two. Finally, the study compared the objective assessments for both hearing and cognition to see if there was any correlation. A series of objectives evaluations and subjective surveys were administered to Primary Participants and their Communicative Partners. Results were analyzed using Paired T-Tests and a Pearson Correlation Procedure.

A significant negative correlation was found in the relationship between the *MoCA* and the *Low-Frequency Pure Tone Average*. This result means as the scores on the *MoCA* decreased, indicating lower cognitive function, the *Low-Frequency Pure Tone Average* increased, indicating a poorer hearing threshold. This correlation suggests that less access to sound, the result of a more severe hearing loss, negatively impacted the cognitive function of the individual. Difficulty hearing may result in less communication and that lack of interaction may negatively impact cognition This finding compares well with the research by Lin et al., (2013) and Livingstone et al., (2017) which found that hearing loss was associated with cognitive decline.

There were significant correlations between the *Low-Frequency Pure Tone Average* and *High-Frequency Pure Tone Average* as well as *High-Frequency Pure Tone Average* and *Word Recognition in Noise*. These were not examined in this study due to the prior understanding that a relationship between these assessments would occur. All

are related to the severity of a hearing loss and it is logical that they would be related to each other.

There was also a positive significant correlation between the *Symptoms of Early Dementia-Primary Participant* and both the *Low-Frequency Pure Tone Average* and *High-Frequency Pure Tone Average*. It was observed that when the scores increased for the *SED-PP*, suggesting a higher perceived cognitive loss, the thresholds for both *LPTA* and *HPTA* increased, meaning poorer hearing. While this was not something examined in the current study, the results could assist with the understanding of a relationship between hearing and cognitive function.

Surprisingly, the results showed the Primary Participants and their Communicative Partners subjectively perceived the loss of functions similarly. While this is good for the relationship and how the two communicate about the loss of function, it might not be an everyday thing. There could be times where the Primary Participant and the Communicative Partner argue on the function. For example, the Primary Participant might blame their partner for mumbling or not speaking loudly enough. The surveys were completed in a separate room, meaning the pair could not communicate about their answers. It is possible the Primary Participant, knowing the purpose of this study and being alone with their thoughts, came to an understanding or realization of their true function. It is important to include one's Communicative Partner during a hearing evaluation, as they might provide insight and information to the clinician. Filling out surveys in separate rooms may give a higher chance of honesty in the surveys. If a future study included two groups---that is both persons with hearing losses who wore

amplification and persons with hearing loss who were not wearing amplification---a difference in the perceptions would most likely be found.

While the results indicated the Primary Participants and their Communicative Partner viewed the function of the Primary Participant the same, there was an outlier. One Primary Participant did not perceive any loss of function in both hearing and cognition. During the surveys completed, she indicated no hearing or cognitive decline. However, her Communicative Partner's survey did indicate both a hearing and cognitive decline. The results of the objective assessments for both functions also showed a hearing and cognitive decline. This outcome was very interesting and suggests she was either clueless of the loss of function, or possibly embarrassed by it. It is very common for individuals to feel ashamed by loss of function, so it is crucial to remind people how widespread loss is in the geriatric population.

Another interesting find was the use of hearing aids. There were four Primary Participants who wore hearing aids (Table 1). When answering the survey, the investigator had them, and their Communicative Partner, answer as they currently were with hearing aids. However, they were also instructed to think back to their function prior to hearing aids, meaning they performed both surveys twice. While the answers in the past were not most accurate due to the factor of time, it was still clear their hearing aids had positively impacted their lives. Each of the four Primary Participants and their Communicative Partner's results of the surveys drastically improved from the time before hearing aids to the time with hearing aids.

Primary Participants with hearing aids were also instructed to perform the *Word Recognition in Noise* while wearing their hearing aids. As stated in Martin et al., word

recognition in noisy environments is more challenging for the geriatric population compared to the younger population (2005). This could be due to either their hearing limitations, cognitive function, or both. Because of this, it is very crucial they have proper amplification that can assist in these noisy environments. Of the four Primary Participants, only one had decent word recognition in noise when compared to their word recognition from inserts (Table 6). Hearing aids are intended to help the individual in dialogue so they can remain involved in conversations. These results suggest the other three participants need to visit their Audiologist to adjust their hearing aids for noisy environments. However, it is important to note factors, such as how long the participant has worn hearing aids, were not collected. Such factors would help the variability and understanding.

As stated earlier, the parameters of this study were altered due to COVID. The investigator had plans to recruit both hearing impaired and non-hearing-impaired participants from local assistive homes and communities. This would have increased the total number of participants as well as decrease the variability of the participants. Two distinctive groups of participants, hearing impaired and non-hearing-impaired, would have allowed for a better comparison. In this field of study, a larger N is important because of variability. This study's low N played a role in the results regarding the recognized high variability of the population of persons with hearing loss. The combination of a low number of participants and high variability made a significant result less likely.

Another possibility is the use of the chosen subjective measures of perception, the *HHIES* and the *SED-11Q*. Neither may have been sensitive enough to measure hearing

impairment or mild cognitive function accurately. Modifying these subjective measures to question each participant possibly could have introduced a factor that, again, was not sensitive to measure the designed construct. The chosen objective measure for cognitive function, the *MoCA*, was a screener and not used to diagnose one with a cognitive decline. These are all possible factors that could have negatively influenced the study at hand.

In conclusion, the results of this study do correlate with past research done on this topic. While there was only one significant correlation found, it implies a relationship between cognitive function and hearing. Overall, worse hearing was noticed to match with lower cognitive function. While there was no correlation found in the perceptions of hearing and cognitive function, this suggests the Primary Participant and their Communicative Partner are understanding of the Primary Participant's function. Further research, with two control groups, is needed on the perceptions of the function. A larger participant total is also needed in future research on this topic to have less variability. This study can help with noting the importance of hearing and aiding a hearing decline, as a loss in hearing relates to cognitive decline.

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Table 1

PARTICIPANT	AGE	GENDER	EDUCATION	AIDED
PP1	76	F	12 years	yes
PP2	75	M	>12 years	yes
PP3	76	F	12 years	no
PP4	78	F	12 years	no
PP5	69	M	>12 years	no
PP6	67	F	>12 years	no
PP7	79	F	12 years	no
PP8	80	M	12 years	yes
PP9	71	M	>12 years	no
PP10	65	M	>12 years	no
PP11	71	M	12 years	yes
PP12	70	F	>12 years	no

Note: This table shows the demographics collected from the Primary Participant. The average age is 73. 50% is male and the other half is female. 50% only have a high school education, and 33% have hearing aids.

Table 2

Participants	*LPTA*	*HPTA*	*WRN*	*MoCA*	*HHIES-PP*	*SED-PP*
PP1	35dB	57dB	88%	23	0	7
PP2	17dB	43dB	76%	22	8	2
PP3	20dB	33dB	96%	18	0	1
PP4	35dB	52dB	60%	16	0	0
PP5	35dB	47dB	52%	18	16	4
PP6	25dB	32dB	92%	22	0	0
PP7	28dB	35dB	80%	18	4	2
PP8	50dB	57dB	44%	18	0	7
PP9	22dB	35dB	72%	23	28	3
PP10	15dB	27dB	92%	27	4	0
PP11	17dB	53dB	56%	26	24	4
PP12	25dB	42dB	88%	24	16	0

Note: This table shows the Primary Participant's raw scores from both the objective and subjective assessments.

Table 3

Participant	*HHIES-CP*	*SED-CP*
CP1	10	3
CP2	20	0
CP3	8	1
CP4	18	5
CP5	0	0
CP6	24	9
CP7	12	3
CP8	8	4
CP9	20	1
CP10	2	0
CP11	22	2
CP12	28	1

Note: This table shows the Communicative Partner's raw scores for the subjective assessments.

Table 4

	T-test	DF
HHIES-PP and HHIES-CP	-1.858	11
SED-PP and SED-CP	0.075	11

Note: This table shows the t-test scores for differences in Primary Participant and Communicative Partner's subjective assessments. There was no significant correlation.

Table 5.

		LPTA	HPTA	WRN	MoCA	HHIES-PP	SED-PP	HHIES-CP	SED-CP
LPTA	Pearson Correlation								
	N	12							
HPTA	Pearson Correlation	0.646							
	Sig. (2-tailed)	0.023							
	N	12	12						
WRN	Pearson Correlation	-0.563	-0.672						
	Sig. (2-tailed)	0.056	0.017						
	N	12	12	12					
MoCA	Pearson Correlation	-0.621	-0.225	0.35					
	Sig. (2-tailed)	0.031	0.481	0.265					
	N	12	12	12	12				
HHIES-PP	Pearson Correlation	-0.357	-0.006	-0.288	0.429				
	Sig. (2-tailed)	0.254	0.985	0.364	0.164				
	N	12	12	12	12	12			
SED-PP	Pearson Correlation	0.584	0.71	-0.517	-0.074	0.063			
	Sig. (2-tailed)	0.046	0.01	0.085	0.819	0.847			
	N	12	12	12	12	12	12		
HHIES-CP	Pearson Correlation	-0.283	0.017	0.141	0.265	0.319	-0.332		
	Sig. (2-tailed)	0.373	0.959	0.663	0.405	0.312	0.292		
	N	12	12	12	12	12	12	12	
SED-CP	Pearson Correlation	0.36	0.093	0.021	-0.253	-0.466	-0.073	0.34	
	Sig. (2-tailed)	0.25	0.773	0.949	0.428	0.127	0.821	0.28	
	N	12	12	12	12	12	12	12	12

Note: This table shows the Pearson Correlation between all the variables found in this study. Regarding the questions asked in this study, the only significant correlation was found between the *MoCA* and *LPTA*. However, there were also significant correlations found between *LPTA* and *HPTA*, *WRN* and both *LPTA* and *HPTA*, *SED-PP* and *LPTA*, and *SED-PP* and *WRN*.

Table 6.

	WRR	WRL	WRN
PP1	79%	84%	88%
PP2	92%	96%	76%
PP8	96%	0%	44%
PP11	96%	96%	56%

Note: This table shows the results of Word Recognition in the right ear, left ear, and sound field for participants with hearing aids.

Appendix A
Approved Recruitment Email

Primary Investigator(s)	Laura Grimes	**Student ☒**
Contact information	leg4b@mtmail.mtsu.edu, (731) 988-8822	
Department & Institution	Middle Tennessee State University	
Faculty Advisor	Rebecca Fischer ***MTSU Department*** Health and Human Performance	
Study Title	The Relationship Between Hearing and Cognitive Function in the Geriatric Population	
IRB ID	**21-2120 47i** **Approval: 03/05/2021**	**Expiration: 03/31/2022**

Dear Potential Participants,
Thank you for your interest in participating in my research thesis. The primary goal of this study is to learn more about the relationship between hearing and cognition, as well as look into the differences of perception of function between you and your communication partner. I am hopeful the results of this study will allow others to realize how hearing and cognition are related, and the importance of intervention when it comes to hearing loss.

Here are the IRB details of this project:

- Title: The Relationship Between Hearing and Cognitive Function in the Geriatric Population
- Principal investigator: Laura Grimes
- Contact Details: leg4b@mtmail.mtsu.edu, (731) 988-8822
- Protocol ID:21-2120 47i Approval: 03.05.2021 Expiration:03/31/2022

We will be scheduling your formal hearing evaluation, cognitive screening, and interviews in the months of February and March. We will schedule you and your partner at your convenience during times when there is little foot traffic. On top of that, I will be cleaning the clinic rooms, door handles, and other areas you will be in contact with. We will also require you to wear a facemask, and we will check your temperature before we begin. We will wear a facemask and a face shield. This is all in hopes of limiting the chances of exposure to the Covid virus for both you, your communicative partner, and my research team. During the fall semester we saw over 20 families in our clinic and did not have one Covid transmission!! So we anticipate a safe spring semester as well.
On the day of your appointment, we ask you allow two and a half hours for the completion of your hearing test, cognitive screening, and surveys. We also ask that both you and your communicative partner arrive together and on time. If your communicative partner cannot come, you will need to inform us prior to the appointment time. We will schedule a separate time to meet with your communicative partner via Zoom, phone, or in person.
You and your communication partner will each sign a consent form when you arrive. will need to bring the signed consent form and completed client history form, attached to this letter, with you on the day of your appointment. Your confidential information will not be shared and will be kept safe within my faculty advisor's office. If you have any questions regarding the safety of your information, feel free to contact me.

After the completion of the study, the primary participant will receive a $10 Visa gift card. This gift card will be mailed to you, or I can give it to a relative I am in touch with to give to you. If you have any questions regarding any aspect of the study, feel free to reach out to me. You may text or call me at (731) 988-8822 and my email address is leg4b@mtmail.mtsu.edu.
Again, thank you so much for your participation in this study!

Laura Grimes

IRB
INSTITUTIONAL REVIEW BOARD
Office of Research Compliance,
010A Sam Ingram Building,
2269 Middle Tennessee Blvd
Murfreesboro, TN 37129
FWA: 00005331/IRB Regn. 0003571

MIDDLE TENNESSEE STATE UNIVERSITY

IRBN001 - EXPEDITED PROTOCOL APPROVAL NOTICE

Friday, March 05, 2021

Protocol Title	***The Relationship Between Hearing Status and Cognitive Function in the Geriatric Population***
Protocol ID	**21-2120 47i**
Principal Investigator	**Laura Grimes** (Student)
Faculty Advisor	Rebecca Fischer
Co-Investigators	Janna Spada (js2ab)
Investigator Email(s)	*leg4b@Mtmail.mtsu.edu; rebecca.fischer@mtsu.edu*
Department	Health and Human Performance
Funding	**NONE**

Dear Investigator(s),

The above identified research proposal has been reviewed by the MTSU IRB through the **EXPEDITED** mechanism under 45 CFR 46.110 and 21 CFR 56.110 within a PRIMARY category *(4) Collection of data through noninvasive procedures* and a SECONDARY category *(7) Research on individual or group characteristics or behavior.* A summary of the IRB action on this protocol is given below:

IRB Action	**APPROVED for ONE YEAR**		
Date of Expiration	**3/31/2022**	*Date of Approval:* 3/5/21	*Recent Amendment:* NONE
Sample Size	THIRTY (30)		
Participant Pool	*Target Population:* Primary Classification: **Seniors within the age group 65 to 85** Specific Classification: **None specific**		
Type of Interaction	☐ Non-interventional or Data Analysis ☐ Virtual/Remote/Online interaction ☒ **In person or physical interaction – Mandatory COVID-19 Management**		
Exceptions	Contact information is permitted to coordinate this research		
Restrictions	**1. Mandatory SIGNED Informed Consent.** **2. Other than the exceptions above, identifiable data/artifacts, such as, audio/video data, photographs, handwriting samples, personal address, driving records, social security number, and etc., MUST NOT be collected. Recorded identifiable information must be deidentified as described in the protocol.** **3. Mandatory Final report (refer last page).** **4. The protocol details must not be included in the compensation receipt.** **5. CDC guidelines and MTSU safe practice must be followed**		
Approved Templates	*IRB Templates:* Signature Informed Consent *Non-MTSU Templates:* Recruitment Email and Debriefing Script		
Research Inducement	$10 gift card; protocol details must not be displayed in the cash receipt		
Comments	NONE		

Post-approval Requirements

The PI and FA must read and abide by the post-approval conditions (Refer "*Quick Links*" in the bottom):

- ***Reporting Adverse Events:*** The PI must report research-related adversities suffered by the participants, deviations from the protocol, misconduct, and etc., within 48 hours from when they were discovered.
- ***Final Report:*** The FA is responsible for submitting a final report to close-out this protocol before **3/31/2022** **(Refer to the Continuing Review section below)**; REMINDERS WILLNOT BE SENT. **Failure to close-out or request for a continuing review may result in penalties** including cancellation of the data collected using this protocol and/or withholding student diploma.
- ***Protocol Amendments***: An IRB approval must be obtained for all types of amendments, such as: addition/removal of subject population or investigating team; sample size increases; changes to the research sites (appropriate permission letter(s) may be needed); alternation to funding; and etc. The proposed amendments must be requested by the FA in an addendum request form. The proposed changes must be consistent with the approval category and they must comply with expedited review requirements
- ***Research Participant Compensation:*** Compensation for research participation must be awarded as proposed in Chapter 6 of the Expedited protocol. The documentation of the monetary compensation must Appendix J and MUST NOT include protocol details when reporting to the MTSU Business Office.
- ***COVID-19:*** Regardless whether this study poses a threat to the participants or not, refer to the COVID-19 Management section for important information for the FA.

Continuing Review (The PI has requested early termination)

Although this protocol can be continued for up to THREE years, The PI has opted to end the study by **3/31/2022** **The PI must close-out this protocol by submitting a final report before 3/31/2022 Failure to close-out may result in penalties that include cancellation of the data collected using this protocol and delays in graduation of the student PI.**

Post-approval Protocol Amendments:

The current MTSU IRB policies allow the investigators to implement minor and significant amendments that would fit within this approval category. ***Only TWO procedural amendments will be entertained per year*** *(changes like addition/removal of research personnel are not restricted by this rule).*

Date	Amendment(s)	IRB Comments
NONE	NONE.	NONE

Other Post-approval Actions:

The following actions are done subsequent to the approval of this protocol on request by the PI/FA or on recommendation by the IRB or by both.

Date	IRB Action(s)	IRB Comments
NONE	NONE	NONE

COVID-19 Management:

The PI must follow social distancing guidelines and other practices to avoid viral exposure to the participants and other workers when physical contact with the subjects is made during the study.

- The study must be stopped if a participant or an investigator should test positive for COVID-19 within 14 days of the research interaction. This must be reported to the IRB as an "adverse event."
- The MTSU's "Return-to-work" questionnaire found in Pipeline must be filled by the investigators on the day of the research interaction prior to physical contact.
- PPE must be worn if the participant would be within 6 feet from the each other or with an investigator.
- Physical surfaces that will come in contact with the participants must be sanitized between use
- **FA's Responsibility:** The FA is given the administrative authority to make emergency changes to protect the wellbeing of the participants and student researchers during the COVID-19 pandemic. However, the FA must notify the IRB after such changes have been made. The IRB will audit the changes at a later date and the FA will be instructed to carryout remedial measures if needed.

Data Management & Storage:

All research-related records (signed consent forms, investigator training and etc.) must be retained by the PI or the faculty advisor (if the PI is a student) at the secure location mentioned in the protocol application.

The data must be stored for at least three (3) years after the study is closed. Additional Tennessee State data retention requirement may apply (*refer "Quick Links" for MTSU policy 129 below*). The data may be destroyed in a manner that maintains confidentiality and anonymity of the research subjects.

The MTSU IRB reserves the right to modify/update the approval criteria or change/cancel the terms listed in this letter without prior notice. Be advised that IRB also reserves the right to inspect or audit your records if needed.

Sincerely,

Institutional Review Board
Middle Tennessee State University

Quick Links:

- Post-approval Responsibilities: http://www.mtsu.edu/irb/FAQ/PostApprovalResponsibilities.php
- Expedited Procedures: https://mtsu.edu/irb/ExpeditedProcedures.php
- MTSU Policy 129: Records retention & Disposal: https://www.mtsu.edu/policies/general/129.php

IRB
INSTITUTIONAL REVIEW BOARD
Office of Research Compliance,
010A Sam Ingram Building,
2269 Middle Tennessee Blvd
Murfreesboro, TN 37129

MIDDLE TENNESSEE STATE UNIVERSITY

IRBF016 – Participant Informed Consent
A. INFORMATION AND DISCLOSURE SEGMENT
(Participant Copy)

Primary Investigator(s)	Laura Grimes		**Student** ☒
Contact information	leg4b@mtmail.mtsu.edu, (731) 988-8822		
Department & Institution	Middle Tennessee State University		
Faculty Advisor	Rebecca Fischer	***MTSU Department***	Health and Human Performance
Study Title	The Relationship Between Hearing and Cognitive Function in the Geriatric Population		
IRB ID	**21-2120 47i**	**Approval: 03/05/2021**	**Expiration: 03/31/2022**

The following information is provided to inform you about the research project in which you have been invited to participate. Please read this disclosure and feel free to ask any questions. The investigators must answer all of your questions and you must be given a signed copy of this disclosure.

- Your participation in this research study is voluntary.
- You are also free to withdraw from this study at any time without loss of any benefits.
- In the event new information becomes available that may affect the risks or benefits associated with this research study, you will be notified so that you can make an informed decision at that time.

For additional information on your rights as a participant in this study, please contact the Middle Tennessee State University (MTSU) Office of Compliance (Tel 615-494-8918 or send your emails to irb_information@mtsu.edu. (URL: http://www.mtsu.edu/irb).

Please read this section and sign Section B if you wish to enroll in this study. The researcher will provide you with a copy of this disclosure form for you to keep for your future reference.

1. **What are the prime types of physical contact the participant will have?**
   The participant will have the following type(s) of contact(s) with the investigators or/and other participants at least sometimes during this research:
   - ☐ 1.1 ***Virtual Interactions*** NONE
   - ☒ 1.2 ***In person interactions***
     - ☒ With PPE ☐ Without PPE ☒ With Social Distancing ☐ Without Social Distancing

2. **What is the main category of this research?**
   - ☐ 2.1 ***Educational Tests***
   - ☐ 2.3 ***Psychological intervention or procedures***
   - ☐ 2.5 ***Medical Evaluation***
   - ☒ 2.2 ***Social/Behavioral Evaluation***
   - ☒ 2.4 ***Physical Evaluation or Procedures***
   - ☐ *2.6 Clinical Research*

3. **What is the purpose of this study?**
   We are trying to answer the following questions:
   1. Is there a difference in the subjective perception of the hearing handicap between the person with potential hearing impairment and their communicative partner?
   2. Is there a difference in the subjective perception of the cognitive status between the participant and their communicative partner?
   3. Is there a difference between the objective assessments of hearing and the subjective perception of hearing?

4. Is there a difference between the objective assessments of cognitive function and the subjective perception of the cognitive status?
5. Is there a relationship between the objective cognitive screening and objective hearing evaluation results?

4. **What type of data will be collected from you?**
Data will be collected from both the Primary Participant and their Communicative Partner.
The Primary Participant will give data on their objective hearing and cognitive function, as well as their subjective opinion of the function of their hearing and cognition.
The Communicative Partner will give data on their subjective opinion of the Primary Participant's hearing and cognitive function.

5. **What are procedures we intend on doing to collect the above described data?**
Procedures for this study include:
A survey for both the Primary Participant and their Communicative Partner on the hearing function of the Primary Participant.
A survey for both the Primary Participant and their Communicative Partner on the cognitive function of the Primary Participant.
A Formal Hearing Evaluation for the Primary Participant.
Montreal Cognitive Assessment for the Primary Participant.
☐ 5.1 *Audio recording* ☐ 5.2 *Video Recording* ☐ 5.3 *Photography* ☒ 5.4 *NO audio/video recording*

6. **What will you be asked to do in this study?**
Primary Participants and the Communicative Partner will be asked to complete a survey on the hearing and cognitive function of the Primary Participant.
The Primary Participant will then be asked to complete the Montreal Cognitive Assessment and a Formal Hearing Evaluation.

7. **What are we planning to do with the data collected using your participation?**
The data collected will be used to answer the questions found under the purpose of the study.

8. **What are the expected results of this study and how will they be disseminated?**
The expected results are that Primary Participants who exhibit a hearing loss will also exhibit a level of cognitive decline.
Comparing the results of the Primary Participant's surveys with the Communicative Partner's surveys will show that the two have different views and opinions of the Primary Participant's hearing and cognitive function. Most likely the Communicative Partner will rate the Primary Participant's function lower than the Primary Participant will rate their function.
Once completed, the investigators look to publish this work in order to spread the information attained.

9. **What is the approximate time commitment not including your preparation time for participating in this study?**
All participants are asked to allot 2 hours total to complete the study. The Communicative Partner might wish to bring a book or magazine to read while waiting on the Primary Participant to complete their Formal Hearing Evaluation and Montreal Cognitive Assessment.

10. **What are your expected costs to you, your effort, and etc.?**
There are no costs associated with this study. You are expected to provide your own transportation to the Hearing Clinic. You are also expected to answer the questions truthfully and to the best of your ability. Primary Participants are also expected to attend to the questions on the Montreal Cognitive Assessment and to carefully listen for the sounds presented during the Formal Hearing Evaluation.

11. What are the potential discomforts, inconveniences, and/or possible risks that can be reasonably expected as a result of participation in this study?

A potential discomfort is the possiblilty of discovering you have a hearing or cognitive decline. However, it is important to note the Montreal Cognitive Assessment is not a diagnostic tool. Primary Participants might become tired from the length of the Formal Hearing Evaluation, but they will be offered a break halfway through.

12. What are the risks and bodily harm due to COVID-19 exposure?

Although the MTSU IRB considers this research as "no more than minimal risk." the participants will be in physical contact with the PI and other participants during this study. Therefore, the participants will be exposed to the risk of contracting COVID-19.

The participants must adhere by the following to reduce the risk for infection.

- Prior to your appointment, all surfaces in the Hearing Clinic will be cleaned with a disinfectant wipe that kills 99.9% of bacteria in 15 seconds. Hand sanitizer will be available at all times. Participants will have their temperature checked and asked a series of screening questions prior to beginning data collection. If participants answer "Yes" to any questions or have a temperature of 100.4 degrees or greater, testing wil be terminated.
- All participants will be required to wear a mask. To reduce COVID-19 exposure, Participants and their Communicative Partners will be seated 6 feet away from the Investigators during administration of surveys, cognitive testing, and hearing testing.
- Two procedures will require close contact between the Participant and the Investigator (placing headphones on participants and performing tympanometry) These procedures can be performed within a maximum of five minutes of close distance exposure. During these procedures, participants and investigators will wear masks, and investigators will wear sheilds as well.

The investigator will follow these precautions:

- Investigators will have their temperature checked and asked a series of screening questions prior to meeting with Participants and their Communicative Partners. If investigators answer "Yes" to any questions or have a temperature of 100.4 degrees or greater, the investigator will be sent home and quarantined according to CDC recommended guidelines and testing will be postponed.
- In the event that a Participant, Communicative Partner, or Investigator should test positive for COVID-19, the information will be provided to the University COVID-19 Task Force or other public health officials.

13. What are the anticipated benefits from this study?

a. ***The benefits to science and humankind that may result from this research:*** Having a better understanding of the relationship between hearing and cognitive function can aid in the fight against dementia and other cognitive deficits. Improving the quality of life for the geriatric population is important because of how much longer individuals are living.

b. ***The direct benefits to you:*** Primary Participants are receiving a free Formal Hearing Evaluation and Cognitive screening.

14. How will you be compensated for your participation?

Primary Participants will receive a free Formal Hearing Evaluation and Cognitive screening. Each dyad of a Primary Participant and Communicative Partner will receive a $10 giftcard of their choice.

15. Are there any alternatives to this study such that you could receive the same benefits?

Participants could receive the same benefits from elsewhere, but they would have to pay for the services.

16. **Will you be compensated for any study-related injuries?**
No

17. **Circumstances under which the researcher may withdraw you from this study:**
The researcher may withdraw you from this study if the subject cannot complete the Montreal Cognitive Assessment or the Formal Hearing Evaluation.

18. **What happens if you choose to withdraw your participation?**
You may choose to withdraw your participation in this study whenever you please. You will still receive the $10 giftcard if you are sign the consent form.

19. **Can you stop the participation any time after initially agreeing to give consent/assent?**
Yes.

20. **Contact Information.** If you should have any questions about this research study or possibly injury, please feel free to contact Laura Grimes by telephone (731) 988-8822 or by email leg4b@mtmail.mtsu.edu OR my faculty advisor, Rebecca Fischer, at (615) 318-0925. For additional information about giving consent of your rights as a participant in this study, to discuss problems, concerns and questions, or to offer input, please feel free to contact the MTSU IRB by email: compliance@mtsu.edu or by telephone (615) 494 8918.

21. **Confidentiality.** All efforts, within reason, will be made to keep your personal information private but total privacy cannot be promised. Your information may be shared with MTSU or the government, such as the Middle Tennessee State University Institutional Review Board, Federal Government Office for Human Research Protections, *if* you or someone else is in danger or if we are required to do so by law.

22. **Confidentiality and COVID-19:** Your information will be provided to the University COVID-19 task force or other public health officials in the event you or one of the research participants or investigators should test positive for COVID-19.

You do not have to do anything if you decide not to participate. If you wish to enroll however, please enter your name and age in the attached Segment B document and sign in the space provided.

Consent obtained by:

_____ _____

Researcher's Signature Name and Title Date

IRBF016 – Participant Informed Consent

B. Consent Segment 1 - IN PERSON INTERACTION
(Researchers' Copy)

Primary Investigator(s)	Laura Grimes		**Student ☒**
Contact information	leg4b@mtmail.mtsu.edu, (731) 988-8822		
Department & Institution	Middle Tennessee State University		
Faculty Advisor	Rebecca Fischer	***MTSU Department***	Health and Human Performance
Study Title	The Relationship Between Hearing and Cognitive Function in the Geriatric Population		
IRB ID	**21-2120 47i**	**Approval: 03/05/2021**	**Expiration: 03/31/2022**

PARTICIPANT SECTION
(To be filled by the participant and returned to the researcher)

Please review and respond appropriately	**Participants give consent**
I have read this informed consent document	☐No ☐Yes
The research procedures to be conducted have been explained to me verbally	☐No ☐Yes
I understand all of the interventions and all my questions have been answered	☐No ☐Yes
I am aware of the potential risks of the study	☐No ☐Yes
I agree to allow my information to be retained by the investigator for use in future research studies	☐No ☐Yes
I give permission to share any information collected from me, including audio/video data, with individuals outside this research study	☐No ☐Yes
I give permission to be contacted in the future	☐No ☐Yes

By entering my name and signing below, I affirm that I freely and voluntarily choose to participate in this study. I understand I can withdraw from this study at any time without facing any consequences.

Name and Signature of the Participant Date Participant's Age

RESEARCHER SECTION
(To be filled by an investigator and the FA if applicable)

Informed Consent obtained by:

Name Signature Date

Faculty Verification (if administered by a student)

Name Signature Date

Appendix B

CASE HISTORY ADULT HEARING EVALUATION
Grimes Study

Name_____ Date of Eval _____

Date of Birth_____

1. Please tell us about your hearing concerns.

2. What is your highest level of education? HS ___ College___ Some Post College ___

3. Do you think you have a hearing loss? If so, how long?

4. My hearing is _____.
   A. Better in the right ear. B. Better in the left ear. C. About the same in both ears.

5. Do you have difficulty hearing _____?

A. in noisy places	□ Yes	□ No	D. the television	□ Yes	□ No
B. in quiet places	□ Yes	□ No	E. over the telephone	□ Yes	□ No
C. in restaurants	□ Yes	□ No	F. the direction of sounds	□ Yes	□ No

6. Do you have a history of _____?

A. ear infections	□ Yes	□ No	G. ear pain	□ Yes	□ No
B. allergies	□ Yes	□ No	H. headaches	□ Yes	□ No
C. fluctuation in hearing	□ Yes	□ No	I. ear surgery	□ Yes	□ No
D. dizziness	□ Yes	□ No	J. noise exposure	□ Yes	□ No
E. fullness in ears	□ Yes	□ No	K. ringing or roaring	□ Yes	□ No
F. hearing loss in family	□ Yes	□ No			

7. Have you had _____?

A. meningitis	□ Yes	□ No	G. diabetes	□ Yes	□ No
B. measles	□ Yes	□ No	H. kidney disease	□ Yes	□ No
C. scarlet fever	□ Yes	□ No	I. seizures	□ Yes	□ No
D. tuberculosis	□ Yes	□ No	J. multiple sclerosis	□ Yes	□ No
E. syphilis	□ Yes	□ No	K. concussion	□ Yes	□ No
F. head fracture	□ Yes	□ No	L. chemotherapy	□ Yes	□ No

8. Are you currently taking any medication? □ Yes □ No
   If yes, please list. _____

9. Have you previously worn hearing aids? □ Yes □ No

10. Please use the space below to give us additional information you feel would be helpful to the person testing your hearing.

Appendix C

	Hearing Handicap Inventory for the Elderly Screening (HHIES) **Communication Partner**	Yes (4)	No (0)	Sometimes (2)
E	Does a hearing problem make your partner feel embarrassed when meeting new people?			
E	Does a hearing problem cause your partner to feel frustrated when talking to family members?			
S	Does your partner have difficulty when someone speaks in a whisper?			
E	Does your partner feel handicapped by a hearing problem?			
S	Does a hearing problem cause your partner difficulty when visiting with friends, relatives, or neighbors?			
S	Does a hearing problem cause your partner to attend religious services less than often than they would like?			
E	Does a hearing problem cause your partner to have arguments with family members?			
S	Does a hearing problem cause your partner difficulty when listening to TV or radio?			
E	Do you feel that any difficulty with your partner's hearing limits or hinders their personal or social life?			
S	Does a hearing problem cause your partner difficulty when in a restaurant with relatives or friends?			
	TOTAL SCORE			

Symptoms of Early Dementia- 11 Questionnaire (SEC-11Q) **Communication Partner:**	Yes	No	N/A
My partner talks and asks about the same things repeatedly.			
My partner has become unable to understand the context of facts.			
My partner has become indifferent about clothing and other personal concerns.			
My partner has begun to forget to turn off the faucet and/or close the door, and/or has become unable to clean up properly.			
When doing two things at the same time, my partner forgets one of them.			
My partner has become unable to take medication under proper management.			
My partner has begun to take a longer time to do work, which could be done quickly before.			
My partner has become unable to make a plan.			
My partner cannot understand complex topics.			
My partner has become less interested and willing, and stopped hobbies, etc.			
My partner has become more irritable and suspicious than before.			
Total Score:			

	Hearing Handicap Inventory for the Elderly Screening Version (HHIE-S) **For the Participant:**	Yes (4)	No (0)	Sometimes (2)
E	Does a hearing problem cause you to feel embarrassed when meeting new people?			
E	Does a hearing problem cause you to feel frustrated when talking to members of your family?			
S	Do you have difficulty hearing when someone speaks in a whisper?			
E	Do you feel handicapped by a hearing problem?			
S	Does a hearing problem cause you difficulty when visiting friends, relatives, or neighbors?			
S	Does a hearing problem cause you to attend religious services less often than you would like?			
E	Does a hearing problem cause you to have arguments with family members?			
S	Does a hearing problem cause you difficulty when listening to TV or radio?			
E	Do you feel that any difficulty with your hearing limits or hinders your personal or social life?			
S	Does a hearing problem cause you difficulty when in a restaurant with relatives or friends?			
TOTAL SCORE = _____ (sum of the points assigned to each of the items)				

Symptoms of Early Dementia- 11 Questionnaire (SEC-11Q) **For the Participant:**	Yes	No	N/A
Do you feel that you talk and ask about the same things repeatedly?			
Do you feel that you have become unable to understand the context of facts?			
Have you become indifferent about clothing and other personal concerns?			
Have you begun to forget to turn off the faucet and/or close the door, and/or has become unable to clean up properly?			
When doing two things at the same time, do you forget about one of them?			
Is it hard to take medication under proper management?			
Does it take you a longer time to do work, which could be done quickly before?			
Has it become harder or are you unable to make a plan?			
Is it harder for you to understand complex topics?			
Have you become less interested and willing, and stopped hobbies, etc.?			
Have you become more irritable and suspicious than before?			
Total Score:			

Appendix D

NU6				NU6				NU6			
List 1 Form A Track 6				List 2 Form A Track 7				List 3 Form A Track 8			
Ear-		Ear-		Ear-		Ear-		Ear-		Ear-	
HL-		HL-		HL-		HL-		HL-		HL-	
#0:10		#2:16		#0:10		#2:26		#0:08		#2:32	
1.	laud	26.	love	1.	pick	26.	mill	1.	base	26.	gun
2.	boat	27.	sure	2.	room	27.	hush	2.	mess	27.	jug
3.	pool	28.	knock	3.	nice	28.	shack	3.	cause	28.	sheep
4.	nag	29.	choice	4.	said	29.	read	4.	mop	29.	five
5.	limb	30.	hash	5.	fail	30.	rot	5.	good	30.	rush
6.	shout	31.	lot	6.	south	31.	hate	6.	luck	31.	rat
7.	sub	32.	raid	7.	white	32.	live	7.	walk	32.	void
8.	vine	33.	hurl	8.	keep	33.	book	8.	youth	33.	wire
9.	dime	34.	moon	9.	dead	34.	voice	9.	pane	34.	half
10.	goose	35.	page	10.	loaf	35.	gaze	10.	date	35.	note
11.	whip	36.	yes	11.	dab	36.	pad	11.	peal	36.	when
12.	tough	37.	reach	12.	numb	37.	thought	12.	search	37.	name
13.	puff	38.	king	13.	juice	38.	bought	13.	ditch	38.	thin
14.	keen	39.	home	14.	chief	39.	turn	14.	talk	39.	tell
15.	death	40.	rag	15.	merge	40.	chair	15.	ring	40.	bar
16.	sell	41.	which	16.	wag	41.	lore	16.	germ	41.	mouse
17.	take	42.	weak	17.	rain	42.	bite	17.	life	42.	hire
18.	fall	43.	size	18.	witch	43.	haze	18.	team	43.	cab
19.	raise	44.	mowed	19.	soap	44.	match	19.	lid	44.	hit
20.	third	45.	bean	20.	young	45.	learn	20.	pull	45.	chat
21.	gap	46.	tip	21.	ton	46.	shawl	21.	road	46.	phone
22.	fat	47.	chalk	22.	keg	47.	deep	22.	shall	47.	soup
23.	met	48.	jail	23.	calm	48.	gin	23.	late	48.	dodge
24.	jar	49.	burn	24.	tool	49.	goal	24.	check	49.	seize
25.	door	50.	kite	25.	pike	50.	far	25.	beg	50.	cool

Appendix E

MoCA
MONTREAL COGNITIVE ASSESSMENT

CERTIFICATE OF COMPLETION

This certificate acknowledges that

Laura Grimes

has successfully completed a one hour training and certification to administer and score the Montreal Cognitive Assessment, MoCA. Only health professionals with expertise in cognition can interpret test results.

Completion date: 2020/10/30

Expiration date: 2022/10/30

Student Id: M01385673

USGRILA281113-01

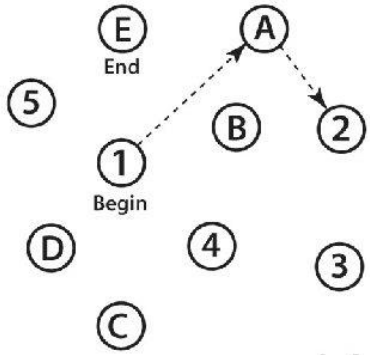
Dr Nasreddine, Ziad

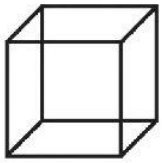
MONTREAL COGNITIVE ASSESSMENT (MOCA)

Version 7.1 Original Version

NAME :
Education : Date of birth :
Sex : DATE :

VISUOSPATIAL / EXECUTIVE





Copy cube

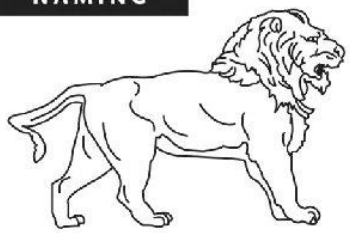
[ ] [ ]

Draw CLOCK (Ten past eleven)
(3 points)

[ ] Contour [ ] Numbers [ ] Hands

POINTS ___/5

NAMING



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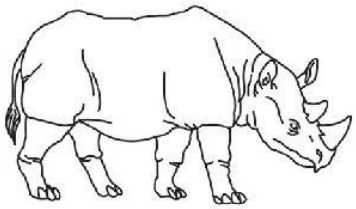

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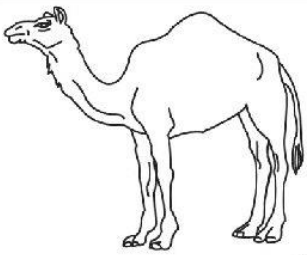

[ ] ___/3

MEMORY

Read list of words, subject must repeat them. Do 2 trials, even if 1st trial is successful. Do a recall after 5 minutes.

	FACE	VELVET	CHURCH	DAISY	RED
1st trial					
2nd trial					

No points

ATTENTION

Read list of digits (1 digit/ sec.).

Subject has to repeat them in the forward order [ ] 2 1 8 5 4

Subject has to repeat them in the backward order [ ] 7 4 2 ___/2

Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors

[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B ___/1

Serial 7 subtraction starting at 100 [ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65

4 or 5 correct subtractions: **3 pts**, 2 or 3 correct: **2 pts**, 1 correct: **1 pt**, 0 correct: **0 pt** ___/3

LANGUAGE

Repeat : I only know that John is the one to help today. [ ]

The cat always hid under the couch when dogs were in the room. [ ] ___/2

Fluency / Name maximum number of words in one minute that begin with the letter F [ ] _____ (N ≥ 11 words) ___/1

ABSTRACTION

Similarity between e.g. banana - orange = fruit [ ] train – bicycle [ ] watch - ruler ___/2

DELAYED RECALL

	Has to recall words WITH NO CUE	FACE	VELVET	CHURCH	DAISY	RED	Points for UNCUED recall only
		[ ]	[ ]	[ ]	[ ]	[ ]	
Optional	Category cue						
	Multiple choice cue						

___/5

ORIENTATION

[ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City ___/6

www.mocatest.org

Normal ≥ 26 / 30

TOTAL ___/30

Add 1 point if ≤ 12 yr edu

Administered by: _____