4-1-2015

Examination of the Effects of Mild Hearing Loss on Memory Using the Wide-Range Assessment of Learning and Memory – Second Edition (WRAML2)

Heather Paige-Deming
George Fox University

This research is a product of the Doctor of Psychology (PsyD) program at George Fox University. Find out more about the program.

Examination of the Effects of Mild Hearing Loss on Memory Using the Wide-Range Assessment

of Learning and Memory – Second Edition (WRAML2)

by

Heather Paige-Deming

Presented to the Faculty of the

Graduate Department of Clinical Psychology

George Fox University

In partial fulfillment

of the requirements for the degree of

Doctor of Psychology

in Clinical Psychology

Newberg, Oregon

Spring, 2015

Examination of the Effects of Mild Hearing Loss on Memory Using the Wide-Range Assessment
of Learning and Memory – Second Edition (WRAML-2)

by

Heather Paige-Deming

has been approved

at the

Graduate Department of Clinical Psychology

George Fox University

As a Dissertation for the PsyD degree

Signatures:

_____

Kathleen Gathercoal PhD, Chair

_____
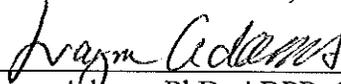
Wayne Adams, PhD, ABPP, Committee Member

_____
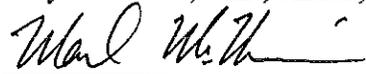
Mark McMinn, PhD, ABPP, Committee Member

Date: 5/20/15

Examination of the Effects of Mild Hearing Loss on Memory Functioning Using the Wide-

Range Assessment of Learning and Memory – Second Edition (WRAML2)

Heather Paige-Deming

Graduate Department of Clinical Psychology at

George Fox University

Newberg, Oregon

Abstract

The current study examined whether young adults with mild hearing loss around 1000 Hz would differ from normal hearing participants in their performance on a standardized memory and learning instrument used in the field of psychology (i.e., WRAML2; Sheslow & Adams, 2003). Participants were 46 normal hearing individuals and 23 individuals with mild hearing loss. Hearing participants were randomly assigned to 1 of 3 groups (hearing control, 23 decibel loss, and 37 decibel loss). All 4 groups completed the WRAML2 under standardized conditions. Based on the effortful hypothesis, it was anticipated that individuals with hearing impairment would show deficits on verbally administered tasks requiring immediate recall. Results indicated that mildly hearing-impaired individuals were as successful as their hearing control counterparts in completing memory tasks efficiently. Only the group with simulated 37 dB hearing loss showed deficits in performance on verbally administered memory tasks with limited contextual information. These results are discussed with regard to adaptation to hearing loss.

Table of Contents

List of Tables

List of Figures

Chapter 1

Introduction

Background

Hearing loss is known to impact many domains of psychological functioning, including social functioning, language comprehension, and cognitive abilities, but conclusions have yet to be drawn about the effect of mild hearing impairment on memory functioning in adults between the ages of 18 to 45 years. Hearing loss is a pervasive problem affecting 10% of the American population, approximately 40 million people ("Prevalence of Hearing Loss," n.d.). The interplay of hearing ability and cognition was a research focus after World War II, however, research in this area significantly decreased for a number of decades, reemerging once again within the last 10 years (Arlinger, Lunner, Lyxell, & Pichora-Fuller, 2009). Advancement in communication technologies, such as hearing aids and cochlear implants, is one of the many factors that renewed interest in the field, perhaps in part due to its relevance to an aging baby-boomer generation. However, the notion that hearing impairment only affects the elderly is a common misconception ("Prevalence of Hearing Loss," n.d.). The Better Hearing Institute website notes that 65% of all hearing loss in the United States occurs in individuals under the age of 65, with more than 6 million incidences of hearing loss occurring between the ages of 18 and 44 ("Prevalence of Hearing Loss," n.d.).

Hearing loss in children has also been extensively studied. Hearing impairment is one of the most common disabilities in children and can have detrimental lifelong consequences with

regard to language and cognitive development without appropriate early intervention (Paludetti, et al., 2012).

Many studies have also concluded that hearing loss is related to cognitive decline in older adults (Shahidipour, Geshani, Jafari, Jalaie, & Khosravidard, 2013; Uhlmann, Teril, Rees, Mozlowski, & Larson, 1989) and new evidence from the Baltimore Longitudinal Study of Aging purports that hearing loss might be a risk factor in incident dementia (Lin et al., 2011). Other studies have shown that verbal memory impairment and decline in memory might be correlated to age-related brain disease (Howieson et al., 1997; Shahidipour et al, 2013).

The bulk of the more recent research regarding hearing loss and cognition has primarily focused on the elderly, on children, and on auditory communication technologies. Researchers have looked at the relationship between memory and hearing loss in adult populations, aged 18 to 45 years, but many these studies have primarily focused on the ramifications of severe-to-profound hearing loss, with less emphasis on how mild hearing deficits can impact an individual's cognitive competency. Addressing hearing loss and its implications is especially important when considering the use of psychological testing.

While recommendations are available on how to appropriately select and administer psychometric psychological tests with hard-of-hearing and deaf individuals, the term hearing impairment complicates matters ("Mild and Unilateral Hearing Loss in Children", n.d.). The term *hearing impairment* is problematic because it is used to categorize all forms and degrees of hearing loss. The overgeneralized definition varies from state to state, and even from practice to practice (Wechsler, 2008). Because there is no one widely accepted definition, misinterpretations of test results and poor recommendations can occur in clinical practice. Additionally,

performance across intellectual domains in the hearing impaired has also been mixed (Domino,

& Domino, 2006).

Early IQ studies found that individuals with hearing impairment struggled while

performing tasks that comprise Verbal IQ measurement, while Braden (1990) and his colleagues

found that Performance IQ was actually lower, albeit still the normal range, for individuals with

hearing impairment when compared with their hearing counterparts on the most commonly used

and widely accepted Wechsler tests (Braden, 1990; Domino, & Domino, 2006). Working

memory and processing speed performance, as measured by the Weschler tests, were also

impacted by hearing loss. Braden's analysis of 21 studies indicated that the Digit Span and

Coding Wechsler subtests were lower, with a mean of 8.77 (versus the expected mean of 10) ,

among deaf individuals than their hearing peers (these two tests were once contributors to Verbal

IQ in the early versions of the Wechsler Scales). Further, another study found that hearing

impaired individuals performed above average on the Block Design and Picture Completion

subtests, two of four subtests that had comprised the Wechsler Performance IQ domain (Domino,

& Domino, 2006).

Interestingly, despite early research findings regarding discrepant results of the hearing

impaired population, many of the cognitive and neurological psychometric tests recommend that

the deaf and hard-of-hearing populations only be administered subtests with minimal verbal

content, unless special accommodations are made to tailor the assessment to the needs of the

individual, such as use of sign language. Furthermore, Domino and Domino (2006) state that

hearing impaired children continue to be evaluated on psychometric tests that have not been

normed on the hearing impaired, but only on their hearing counterparts. While it is recommended

that only tests of non-verbal performance be administered to people with hearing impairment, it

is important to note that many of these studies involving the effect of hearing impairment on the

assessment of intellectual domains have been conducted on children; relatively few studies have

looked at adults with mild hearing disability, especially using psychometric instruments designed

to assess memory.

Hearing Loss

Hearing is measured by assessing sensitivity to sound intensity and pressure, the two

physical correlates of loudness, presented at a variety of frequencies (i.e., pitches). It is most

often measured by audiological or "audiometric testing" conducted in appropriately equipped

laboratories by trained audiologists (Isaacson & Vora, 2003; Maerlender, 2010). Audiometric

testing delivers pure tone sounds of various frequencies to determine an individual's hearing

threshold, defined as the lowest intensity at which various pure tones or words can be detected

50% of the time (Wingfield, Tun, & McCoy, 2005). The patient's thresholds obtained on the

hearing measure are compared to normal hearing at each frequency and the difference is

measured in decibels (dB). In speech testing, another measure of auditory ability, the subject is

presented with a list of words and asked to repeat each word. The degree of speech loss is

calculated by the percentage of words the individual fails to correctly repeat back to the

examiner (Isaacson & Vora, 2003; Isaacson, 2010).

The average human ear can perceive sounds ranging 0 to 200 dB. An individual with very

good hearing can hear sounds as low as -15dB's, the weakest sound a human ear can detect,

whereas 200 dB is the loudest sound. To give some perspective, 20 dB is comparable to the noise

level in a quiet library, while the sound released by a rocket launch is 180 dB. The threshold for

normal hearing falls between 0 and 25 dB. Depending on the severity of loss, the threshold range

for hearing begins to increase. For example, individuals with mild loss can only begin to hear

sounds falling between 25 and 40 dB, and those with moderate loss can start to detect sounds

within the range of 40 dB to 65 dB. Individuals with severe hearing deficits cannot detect sounds

softer than 65 dB and those with profound loss can only hear sounds above 90 dB. As such,

sounds that a normal hearing individual would consider loud are barely audible to those with

moderate hearing impairment. With moderate loss, speech comprehension can become

problematic, creating limitations in language usage, language comprehension and vocabulary.

Language comprehension is extremely impacted with severe loss.

The ability to detect pitch of sound perceived by the human ear, or the frequency of

sound vibrations per second, is also important to the understanding of hearing. The human ear

can detect sounds ranging from 20 to 20,000 Hz with speech frequencies falling in the range of

250 to 8000 Hz (Kutz, 2015). The onset of hearing impairment often impacts higher frequencies

first. High frequency loss typically decreases the clarity of sound, and therefore human speech is

difficult to understand even though it can be heard, particularly when similar sounding words

include high-frequency consonants, such as /f/, /s/, /sh/, and /ch/. This is why individuals with

hearing loss can sometimes struggle to understand women and small children, as those voices

typically have higher frequency tones ("Noise Induced Hearing Loss," 2012).

Because the ear is a sensitive and intricate sensory organ, many aspects of hearing can

become impaired. There are three distinct types of hearing loss seen within medical practice:

conductive, sensorineural, and mixed loss, an impairment that has concomitant conductive and

sensorineural loss (Isaacson & Vora, 2003; Isaacson, 2010).

Sensorineural hearing impairment is caused by dysfunction or damage to the inner ear. This part of the ear houses the cochlea, the organ responsible for converting sound waves to electrical impulses. The cochlea is a delicate structure that can be affected by aging, illness, head trauma, genetics, toxic substances, and congenital defects. Loss of hair cells in the high-frequency region of the basilar membrane of the cochlea causes a loss of acuity for high-frequency sounds. This degeneration can significantly affect speech perception (Wingfield et al., 2005). Other sources of sensorineural loss include damage to the central neural pathways, most often caused by genetic anomalies or trauma.

Conductive loss, which occurs when sound conduction is impeded in either the external or middle ear due to infection, injury, or birth defects, is the second most common form of hearing loss (Isaacson & Vora, 2003; Isaacson, 2010). Conductive hearing loss results when sound cannot efficiently transverse the ear canal, tympanic membrane, and/or ossicular chain of the middle ear (Isaacson, 2010). This type of impairment is typically not as severe as sensorineural loss, with hearing deficits usually falling within the mild to moderate range.

The Effortful Hypothesis

Some studies suggest that hearing loss can negatively impact memory, even when words and other auditory stimuli could be correctly identified by the hearing impaired individual. Rabbitt (1968) proposed the effortful hypothesis to explain this phenomenon (Rabbitt, 1968, 1990). The *effortful hypothesis* suggests that perceptual effort required for speech recognition might draw from attentional resources that would have otherwise been allocated for memory. In short, Rabbitt argued that the hearing impaired listener must invest extra effort in the earlier stages of perceptual processing (Tun, Benichov, & Wingfield, 2010). One of the most common

complaints from people who are hard of hearing is that, although they can understand, listening

takes much of their effort (Pichora-Fuller, 2006). Pichora-Fuller (2006) states that the more

mental energy is spent to achieve the primary goal of understanding, the less remains available

for other goals (Kahneman, 1973; Pichora-Fuller, 2006). Poor language comprehension and

limitations of perceived memory are consequences of effortful listening in both hearing and

hearing loss conditions.

Normal hearing individuals may struggle with memory tasks if background noise masks

auditory stimuli. "If increased listening effort results in the expenditure of limited working

memory resources on perceptual processing, thereby leaving fewer resources remaining for

storage, it would be expected that listeners who are hard-of-hearing would be poorer than normal

hearing listeners" (Pichora-Fuller, 2006, p.77; Van Boxtel et al., 2000; Larsby, Hallgren, Lyxell,

& Arlinger, 2005). One study looked at mild hearing loss and memory difficulties using list

recall. Rabbitt (1990) found that participants with mild hearing loss recalled the list of 15 words

less accurately than the normal hearing control group, although they had repeated each word

correctly when initially presented. Rabbitt (1990) attributed these findings to the fact that the

hearing impaired group allocated their resources to the task of perceiving speech input, leaving

fewer resources for encoding and subsequent recall (Pichora-Fuller, 2006).

Using the *effortful hypothesis* as a foundation, several studies have conducted tasks

requiring immediate free recall of word-lists, or both immediate recall and delayed recall of word

lists, in order to ascertain short-term and/or long-term memory functioning of hearing impaired

individuals (Piquado, Cousins, Wingfield, & Miller, 2010; van Boxtel et al., 2000). While there

is evidence hearing ability plays a role in comprehension, memory performance and verbal

learning performance, studies have yielded inconsistent results. Some studies propose that age

can be used to explain poor performance of free recall tasks rather than hearing ability, and that

these differences increase with age (Rabbitt, 1990; van Boxtel et al., 2000). Others have

suggested that age is not a factor, but rather hearing loss, as an independent factor, imposes extra

burden on processing resources and working memory, thereby negatively affecting word recall.

Many of the tasks used in previous studies have focused on word recall lists or word

recognition tasks in assessing memory and effortful processing. While many of these tasks are

helpful in ascertaining memory abilities, findings based on assessment using standardized

measures are not widely known (Wake, Hughes, Poulakis, Collins & Rickards, 2004).

Children and Measures of Intelligence

As noted earlier in the text, assessing intellectual development and/or functioning of

children have primarily been accomplished by using standardized assessment measures. These

instruments are advantageous because they offer more objectivity than other assessments, have

norms for comparison. However, many researchers have modified the use of standardized testing

when assessing children with hearing loss because they do not want the scores of

auditory/language based subtests to skew results, assuming that the use of such subtests will

penalize children with hearing loss (Plapinger & Sikora, 1995).

Some studies using standardized psychometric tests have focused directly on deaf and

hard-of-hearing children, but have predominantly looked at intelligence rather than specifically

on memory and/or learning. Vernon (2005) reviewed the last 50 years of comparative research

conducted on deaf and hard-of-hearing children with regard to intelligence testing;

approximately 50 studies that have measured IQ in relation to hearing impairment since the

"advent of intelligence testing in the early 1900's" (Vernon, 2005, p.225). Many of these studies

compared hard-of-hearing and normal hearing children's intelligence test performance to the

performance by sub-groups of other hearing impaired individual and to test norms (Vernon,

2005). When those with known biological etiology for intellectual deficit were omitted from the

study, the hearing impaired subjects performed as well on the IQ tests as their normal hearing

counterparts.

Another study by Niedzielski, Humeniuk, Blaziak, and Gwizda, (2006) confirmed that

hearing-impaired children's IQ scores do not significantly differ from those of children with

normal hearing. However, this study also examined whether there were differences in the

development of intellectual functioning among children with unilateral hearing loss (either right-

or left-sided loss) using the *Wechsler Intelligence Scale for Children - Revised*. The authors

found that children with right ear impairment typically had poorer performance on verbal

intelligence when comparing them to children with left-sided loss, whereas non-verbal

intelligence was negatively correlated with left ear impairment (Niedzielski et al., 2006).

While there has been more research dedicated to determining the influence that hearing

loss may have on intelligence, the relationship between mild-to-moderate hearing loss and

memory, particularly within the college-aged, young adult population, have focused on the use of

standardized psychometric measures as a tool to measure memory. The Wide Range Assessment

of Memory and Learning – Second Edition (WRAML2; Sheslow & Adams, 2003) is a

commonly used standardized measure in the field of psychology that is used to evaluate memory

and learning domains.

The Wide Range Assessment of Memory and Learning – Second Edition (WRAML2)

There has been continuing debate regarding the construct of memory. Many theoretical

models have attempted to take the colossal task of understanding and defining the memory

system over the past century, but the clearer picture has begun to emerge within the last 20 years

(Sheslow & Adams, 2003). Recent models of memory propose that memory is active and multi-

systemic set of processes that includes attention, short-term, temporary retention, long-term

storage, executive functioning, and retrieval acquired knowledge (Ericsson & Kintsch, 1995;

Kintsch, Healy, Hegarty, Pennington, & Salthouse, 1999; Sheslow & Adams, 2003). Memory

and learning are interrelated (Wechler, 2008). The WRAML2 is an individually administered

battery of tests designed to examine verbal and visual learning and memory, and it also includes

an attention/concentration component (Hall, 2006).

The WRAML2 is not based specifically on one model of memory, but rather takes a

relatively eclectic approach, conceptualizing memory function and learning as an active and

dynamic system that involves highly complex cognitive processes such as learning, attention and

concentration, and executive functioning (Sheslow & Adams, 2003).

Purpose of the Present Study

The purpose of this study was to assess adults with mild hearing loss and compare their

performance on a variety of memory tasks to normal hearing peers. The current study focused on

adults between 18 and 45 years of age. It is generally assumed that young, healthy adults are not

yet subject to age-related cognitive decline, including reduced memory for incoming information

(Wingfield et al., 2005). The memory and learning tests of the WRAML2 were used to assess

participants' working memory performance, as it has been suggested that working memory is an

important system for cognitive performance and is therefore applicable to the concept of the

effortful hypothesis (Giesbrecht, 2008). This study tested the hypothesis that there would be no

statistically significant differences between working memory subtest scaled scores obtained from

the WRAML2 of adults with mild hearing loss compared to those of their healthy hearing peers.

In sum, the purpose of this research was to study the effect of mild hearing loss in an adult

population on a variety of memory tasks using a standardized memory measure that had not been

standardized on the hearing impaired population.

Chapter 2

Method

Participants

Sixty-nine adults aged 18 to 45 years were participant volunteers in this study. Fifty-six participants were gathered from a convenient sample of George Fox University undergraduate psychology students via a virtual student research board, one that offered class credit for research participation. Thirteen subjects were gathered from local communities via snowball sampling. Participants' hearing was screened and 23 participants with mild hearing loss (ranging from 26 dB to 40 dB) were identified. While it was hypothesized it would be difficult to find a sample with hearing loss, it was relatively easy to find young adults with mild hearing loss, as hearing impairment is a ubiquitous problem across ages. All participants were tested for pure-tone hearing acuity across the frequencies ranging from 250 - 6000 Hz using the program uHear, described below. Volunteers with moderate-to-severe hearing loss were excluded from the study, as were those with no collegiate experience. All participants were required to identify English as their native language. Hearing loss participants were not receiving intervention in the form of cognitive restructuring and/or hearing devices for their loss at the time of administration. 80% of the participants in this study were comprised of individuals between the ages of 18 to 24 years, 71% of the sample was Euro-American, and 54% was female. 46% were male, 29% were classified as bi-racial, and 20% were between the ages of 25 to 45 years of age, with approximately 15% falling between the ages of 25 and 35 years of age.

Instruments

   Wide-Range Assessment of Memory and Learning-II (WRAML2; Sheslow & Adams,

2003) is an individually administered battery of tests designed to assess verbal and visual

learning and memory of individuals between the ages of 5 and 90 years. The adult core battery

provides a General Memory Index, which includes the Verbal Memory, Visual Memory, and

Attention/Concentration indices, and is comprised of six subtests. Seven supplemental subtests

were also included to evaluate delayed recall, recognition, and working memory abilities; two of

these seven subtests examine the Working Memory domain. Testing took approximately 90

minutes, because supplemental tests were included in administration. This study included the full

adult battery, which meant that the both core and optional tests were given to each participant.

Table 1 and Table 2 provide a description of the organization of the fifteen subtests into indices.

Table 1

Core Index Composition for the WRAML2

	Index	Subtest
General Memory Index (GMI)	Verbal Memory Index	Story Memory
		Verbal Learning
	Visual Memory Index	Design Memory
		Picture Memory
	Attention/Concentration Index	Finger Windows
		Number/Letter

Note: Recognition subtests for the Verbal Memory Index and Visual Memory Index form the General

Recognition Index (GRI; Strauss, Sherman, & Spreen, 2006).

Note continues.

The WRA*ML2 Manual* (Sheslow & Adams, 2003) reports Person separation reliabilities for the core subtests range from .85 to .94; the optional subtests range from .56 to .93. Reliability, as measured by internal consistency, is good across indices, ranging from .83 - .95 across the age groups used in this study. Internal consistency of core and optional subtests, including the recall and working memory tests, range from .71 to .94. The recognition subtests used in this study and corresponding age groups have fair internal consistency ranging from .38 to .88, respectively.

Table 2

Optional Subtests and Index Score Composition for the WRAML2

Index	Subtest
Working Memory Index	Verbal Working Memory
	Symbolic Working Memory
Other Optional Subtests	Sentence Memory
Delay Recall Subtests	Story Memory Recall
	Verbal learning recall
Recognition Subtests	Story Recognition
	Design Recognition
	Picture Memory Recognition
	Verbal Learning Recognition

(Strauss, Sherman, & Spreen, 2006)

uHear is a brief hearing screener application, designed by Unitron for the iPhone and iPod Touch that takes approximately eight minutes to complete. The application includes three assessments: Hearing Sensitivity, Speech in Noise, and a 12-item self-report questionnaire used to

assess how well an individual can hear in common listening conditions. The hearing sensitivity test assesses pure-tone frequencies from 250 Hz to 6000 Hz, the frequency range representative of the speech spectrum. The participants were only required to complete the hearing sensitivity test and self-report questionnaire.

The uHear application was downloaded onto three Apple iPod Touch 16 GB MP3 Players (5th Generation) with three sets of identical headphones (Sony Studio Series headphones) for standardization purposes.

In a recent study, Wang, Zupancic, Ray, Cordero, and Demke (2014) tested whether the uHear app was as reliable as traditional audiometric tests. Their study determined that the software was reliable for lower pure-tone frequencies (250 Hz, 500Hz, and 1000Hz) but overestimated hearing loss at higher frequencies (2000 Hz, 4000 Hz, 6000 Hz). Another study looking at the validity of the uHear app found that the application was a successful screener in ruling out moderate hearing loss (pure tone average > 40 dB) and in quantifying the degree of hearing loss in individuals with hearing impairment (Szudez et al., 2012). Neither study advocated using the screener to act as a replacement for traditional audiometric testing methods and recommended that individuals identified with hearing deficits be referred to a hearing healthcare professional (Wang, Zupancic, Ray, Cordero, & Demke, 2014).

Noise reduction headphones were used to create mild simulated hearing loss by masking the hearing of normal hearing participants. The two sets of headphones included were the *3M Peltor Optime 98 cap-mount earmuffs* and the *3M Peltor Ultimate 10 Hearing earmuffs,* both normally used to protect an individual's hearing from loud noises that could potential cause noise-induced hearing loss. The former set had a noise reduction rating of 23 decibels, while the

latter had a noise reduction rating of 30 dB. While not within the mild hearing loss range per se, a simulation of a 23 dB loss was enough of a difference to elicit effort in on memory tasks in normal hearing individuals. The *3M Peltor Ultimate 10 Hearing earmuffs* were used in conjunction with Magid IHP32RF Polyurethane From E2 Disposable Uncorded Foam Earplugs with a noise reduction rating (NRR) of 32 dB to simulate further loss. A website designed for hearing safety reports that the NRR can be increased by using both ear muffs and earplugs concurrently. The headphones are rated to create a 30 dB loss, the ear foam plugs a 32 decibel loss. Therefore, we can calculate high-mild simulated loss had a loss of 37 dB based on the assumed formula ("Double-hearing-protection" n.d.). In summary, low-mild hearing loss (i.e., a 23 dB reduction) was simulated by asking normal hearing participants to wear the *3M Peltor Ultimate 10 Hearing earmuffs,* and a high-mild hearing loss (i.e., a 37 dB reduction) was simulated by asking participants to wear both the *3M Peltor Ultimate 10 Hearing earmuffs* and the ear foam plugs simultaneously.

Procedure

George Fox University Human Subjects Review Committee approved this study. To receive class credit for participation, each volunteer was required to sign the consent form (see Appendix A) and complete a simple demographic survey, which included basic information such as age, sex, race, current year in college, and last degree obtained (see Appendix B). All examiners were doctoral candidates in a clinical psychology program who had successfully demonstrated competency in the administration, scoring and interpretation of the WRAML2. The examiners informed the participants that their participation was voluntary and that they could discontinue involvement without consequence/dispute. The participants were also informed that test records

would be kept confidential per American Psychological Association standards and would be destroyed after seven years.

Examiners met the participants in a waiting room and lead them to private offices for the test administration. After completing the required preliminary forms, hearing ability was assessed using the uHear screener. Each participant with normal hearing ability was then randomly assigned to one of three groups, a hearing control group (Group 1), and two mild simulated loss groups. Participants assigned to Group 2 simulated low-mild hearing loss (i.e., simulated 23 dB loss) and Group 3 simulated high-mild hearing loss (i.e., simulated 37 dB loss) had their hearing masked via sound reduction headphones and earplugs, respectively. Participants who presented with mild hearing loss comprised the fourth group (Group 4). The four groups were comprised of 196 hearing control participants, 13 low-mild simulated loss participants, 14 high-mild simulated loss participants, and 23 participants with mild hearing loss.

The 56 undergraduate participants were assigned to quiet offices on-campus to complete WRAML2 testing in an allotted two-hour time block. The 13 other participants were tested in their homes, free from noise and distraction. The duration of testing ranged from 75 – 120 minutes.

Chapter 3

Results

Fidelity Check on Hearing

The aural sensitivity of the Normal ($n = 46$) and Hearing Loss ($n = 23$) groups differed significantly. Specifically, a 12 (frequencies) by 2 (groups) repeated-measures ANOVA resulted in a significant main effect of frequencies, Greenhouse-Geisser F (6.00, 390.15) = 30.45, $p <$ .001, and a main effect of hearing group, F (1, 65) = 39.85, $p < .001$. But most importantly, there was a significant interaction of frequencies and hearing groups, Greenhouse-Geisser F (6.00, 390.15) = 6.76, $p <$.001. The interaction, shown in Figure 1, indicated that the Hearing Loss group is significantly less sensitive to frequencies lower than 2000 Hz. It is important to note that human speech occupies pure-tone thresholds of 500 Hz, 1000 Hz, and 2000 Hz (Carhart, 1946; Preece & Fowler, 1992)

In order to ensure the groups were comparable before the simulated hearing loss, a 12 (frequencies) by 3 (groups) repeated-measures ANOVA was conducted. This 12 x 3 repeated-measures ANOVA documents that, as would be expected, sensitivity differed across the frequencies Greenhouse-Geisser F(6.63, 278.46) = 18.23, $p <$.001). More importantly, prior to the simulated hearing losses, there were no significant differences in the three groups of normal hearing participants, F(2, 42) = 1.01, $p = .37$, nor was there an interaction of frequency and groups, Greenhouse-Geisser F(13.26, 278.46) = 1.17, $p = .30$).
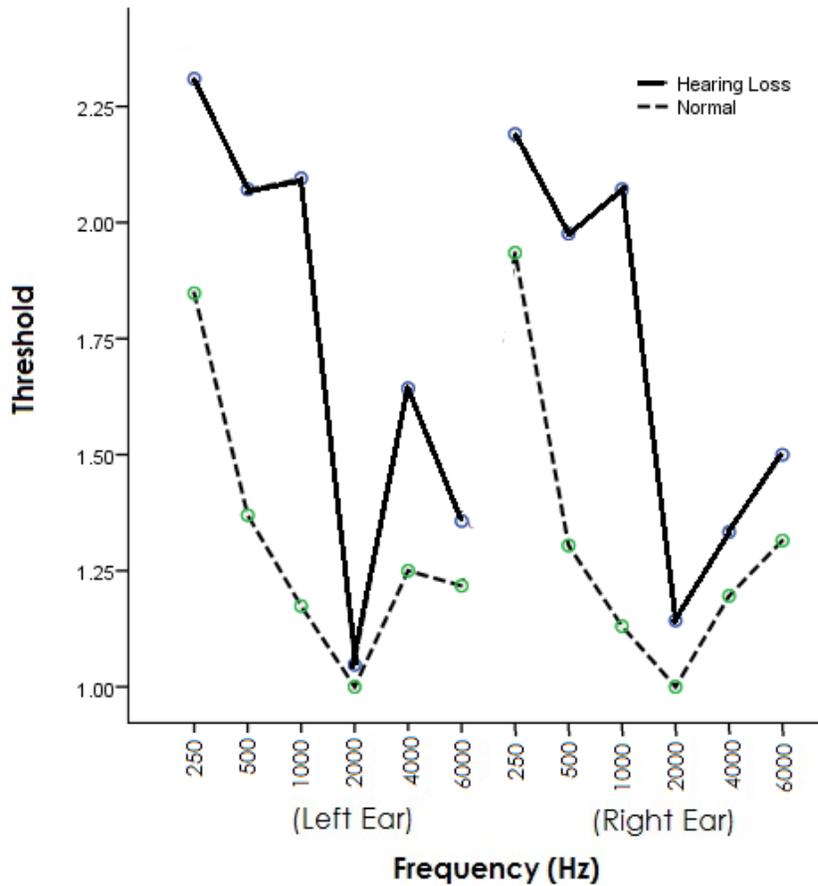
Figure 1. Hearing curves of participants in the Normal and Hearing Loss groups. Threshold

categories were 1 = normal hearing; 2 = mild loss; 3 = moderate loss.

The WRAML2 Subtest Results

The mean scaled scores for each of the 15 WRAML2 subtests for the four groups are

shown in Table 3. It should be noted that scaled score averages range from 8 to 12. Participants

who obtained scaled scores above a 12 performed in the high average (to superior) ranges, and

those with scaled scores below 8 were in the below average (to borderline) ranges. Looking at

Table 3, the reader can see that the means fell within the average range on all but 8.3 % of the

subtests. Above average means only occurred in Groups 1 and 4; below average means occurred

Table 3

Mean WRAML2 subtest scores for the Normal hearing, Simulated Mild Loss, Simulated Moderate Loss, and Hearing Loss groups.

WRAML2 subtest	Normal Hearing M (SD)	Simulated Low-Mild Loss M (SD)	Simulated High-Mild Loss M (SD)	Hearing Loss M (SD)
Story Memory	10.00 (2.91)	10.62 (2.50)	10.57 (2.72)	10.35 (2.28)
Design Memory	10.21 (2.57)	10.46 (1.55)	9.43 (2.50)	10.70 (2.96)
Verbal Learning	11.32 (2.11)	9.92 (3.25)	8.07 (2.13)	9.85 (1.95)
Picture Memory	9.74 (2.79)	8.62 (1.69)	10.00 (2.51)	9.20 (1.91)
Finger Windows	9.89 (2.38)	9.77 (2.55)	9.21 (2.40)	8.90 (1.94)
Number Letter	12.21 (3.16)	9.69 (2.90)	7.86 (3.88)	12.40 (2.52)
Verbal Working	11.63 (2.83)	9.46 (3.67)	9.00 (1.61)	10.85 (2.64)
Symbolic Working	12.00 (2.13)	10.83 (2.55)	9.21 (2.42)	11.20 (1.88)
Sentence Memory	12.16 (2.97)	10.85 (3.63)	8.36 (2.37)	11.10 (2.22)
Story Recall	9.42 (2.41)	10.62 (2.13)	11.07 (2.74)	10.85 (2.72)
Verbal Learning Recall	11.00 (2.23)	9.69 (3.07)	9.79 (2.40)	10.05 (1.64)
Story Recognition	10.89 (3.38)	9.77 (2.04)	10.93 (2.09)	10.80 (2.14)
Design Recognition	9.79 (2.59)	10.38 (2.90)	9.29 (2.31)	10.55 (2.78)
Picture Recognition	10.56 (2.55)	9.62 (2.62)	9.43 (1.76)	8.75 (2.63)
Verbal Learning Recg	10.58 (1.74)	9.92 (2.40)	8.57 (2.24)	9.45 (1.88)

in Group 3, specifically on the Number Letter subtest. The table also shows that the means for

Group 2 and Group 3 were at least one to two scaled scores lower than Group 1 on many of the

subtests. The Hearing Loss group (Group 4) also appeared to be one scaled score lower than

Group 1.

In order to determine whether there were significant differences among the four groups'

scaled score means, a 15 (subtest) by 4 (group) repeated-measures ANOVA was employed. The

ANOVA assumptions were tested. The data were not skewed, however the assumption of

homoscadicity was not met, Mauchly's W (104) = .003, $p < .001$, therefore a Greenhouse-

Geisser ANOVA formula was employed.

The results of the 15 (subtests) by 4 (groups) repeated-measures ANOVA showed a

significant difference among subscores, Greenhouse-Geisser F (3, 38, 528.22) = 2.60, $p = .007$; a

significant difference among the groups $F(3, 63) = 3.80$, $p = .014$; and a significant subtest by

group interaction, Greenhouse-Geisser F (25.15, 528.22) = 2.50, $p < .001$. Power for these

ANOVAs was good for the within-subject tests (i.e., .84 for subtests and .89 for the interaction)

but was quite low for the between-subject test (i.e., .50 for groups).

In order to determine where these differences existed, 15 one-way ANOVAS were run,

one on each of the 15 subtests. The follow-up showed that 5 of the 15 WRAML2 subtests had

significant differences among the four groups, including Verbal Learning Memory, $F(3, 63) =$

5.65, $p = .002$; Number Letter Sequencing, $F(3, 63) = 8.02$, $p < .001$; Verbal Working Memory,

$F(3, 63) = 4.53$, $p = .006$; Symbolic Working Memory, $F(3, 63) = 4.94$, $p = .004$; and Sentence

Memory, $F(3, 63) = 5.72$, $p = .002$. Verbal Learning Recognition was close to showing a

significant difference among the four groups, F (3, 63) = 2.55, $p = .064$ and was therefore

explored to see which of the groups were most dissimilar. The effect sizes indicated no effects or

small effects for the ANOVAs that were not statistically significant and the associated Power

was extremely low too (i.e., Power ranged from .07 to .55). The Effect sizes were large for the

ANOVAs that were statistically significant and the associated Power was adequate (i.e. Power

ranged from .63 to .85).

Figure 2 shows the mean scaled scores for six WRAML2 subtests that had significant

differences among the groups. A Tukey's Honestly Significant Difference

Test (HSD), a conservative post hoc test, was used as a follow-up to each of the six significant

one-way ANOVAs to identify the differences among the four groups for each subtest. Tukey's

HSD revealed that for all six subtests (i.e., Verbal Learning, Letter Number Sequencing, Verbal

Working Memory, Symbolic Working Memory, Sentence Memory, Verbal Learning

Recognition) there were significant differences between Groups 1 (Normal Hearing) and 3 (37

dB Simulated High-Mild Hearing Loss). For the Number Letter subtest, in addition to the

significant difference between Groups 1 and 3, there were also significant differences between

Groups 1 (Normal Hearing) and 2 (23 dB Simulated Low-Mild Hearing Loss), and Goups 3 (37

dB Simulated High-Mild Hearing Loss) and 4 (Mild Hearing Loss).

Examination of the WRAML2 Indices

This study also assessed the groups' performance by domains, or indices. The mean

scaled scores for each of the six WRAML2 domains for the four groups are shown in Table 4.

The Verbal Memory, Visual Memory, and Attention and Concentration Indices are the three core

WRAML2 domains. Working Memory Index scores as well as those from the Verbal

Recognition and Visual Recognition Indices were also calculated. Results are shown as standard

scores (SS) with a statistical mean of 100. Like most psychological tests, standard scores range
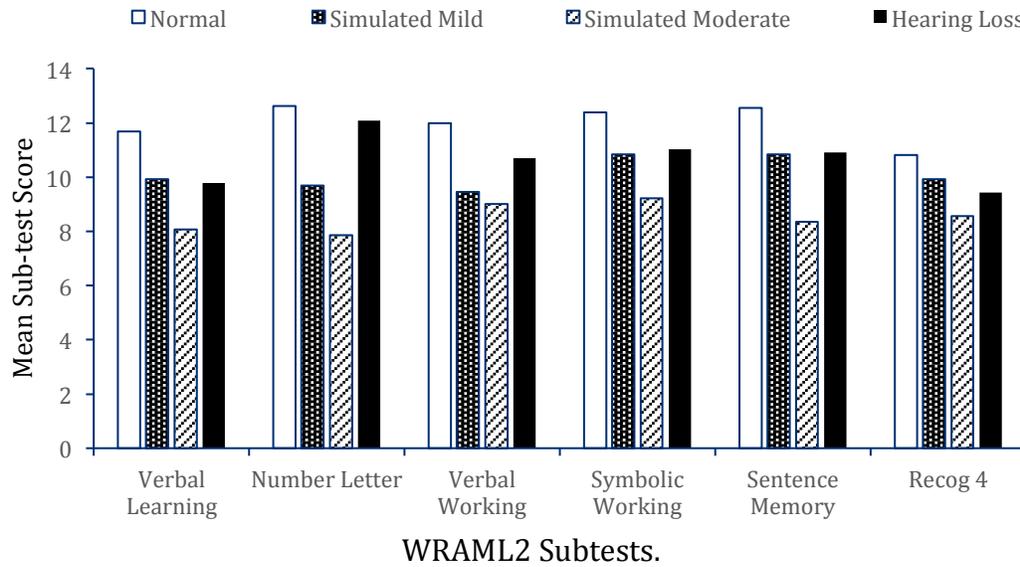
Figure 2. Mean scaled scores for the four groups on six WRAML2 subtests.

from 50 – 160, with 68 percent of the population falling in the range of 85 – 115. Domain mean

scores on all six of the WRAML2 domains fell within the average range (from 91.2 to 111.8).

At first glance, the reader can see from Table 4 that the domain standard scores among

the four groups were highest for Group 1 and lowest for Group 3. This was the case across all

indices, which is what we would expect given the pattern of subtest scores.

In order to determine whether there were significant differences among the four groups'

mean domain scores, a 6 x 4 repeated-measures ANOVA was employed and assumptions were

tested. The data were not skewed and the assumption of equal variances was met, Mauchly's W

$(14) = 1.32$, $p = .07$.

Table 4

Mean WRAML2 domain scores for the Normal hearing, Simulated Mild Loss, Simulated Moderate Loss, and Hearing Loss groups.

WRAML Domain	Normal Hearing	Simulated Mild Loss	Simulated Moderate Loss	Hearing Loss
	M (SD)	M (SD)	M (SD)	M (SD)
Verbal Memory	105.37 (13.02)	101.83 (15.75)	95.71 (10.98)	99.21 (9.61)
Visual Memory	101.88 (11.38)	96.50 (7.33)	98.29 (12.71)	98.30 (11.11)
Attention	108.50 (11.27)	97.17 (13.43)	91.21 (13.44.)	102.30 (10.52)
Working Memory	111.81 (12.19)	100.00 (14.31)	94.85 (9.30)	104.35 (10.11)
Verbal Recognition	106.50 (11.30)	99.00 (11.63)	98.07 (10.81)	98.83 (8.76)
Visual Recognition	101.98 (13.56)	98.33 (15.74)	95.50 (10.53)	96.95 (13.15)

The results showed no significant difference across domains $F (5, 305) = 1.63$, $p = .150$, $eta^2 = .03$ indicating a small effect, Power $= .55$, and all groups responded to the domains in the same way, i.e., there were no interactions, $F (15, 305) = 1.16$, $p = .305$, $eta^2 = .05$ indicating a small effect, Power $= .74$. A significant difference between the four groups was obtained, $F (3, 61) = 5.20$, $p = .003$, $eta^2 = .20$ indicating a large effect, Power $= .91$. To help identify where the significant differences were among the four groups, a Tukey test (HSD) was used in follow-up and revealed that Group 3 performed significantly worse than Group 1 on all domains. No other group comparisons were statistically significantly different.

Chapter 4

Discussion

Summary of Findings

This study investigated whether mild hearing loss affects memory abilities in a young

adult college population using standardized assessment. Results indicated that naturally

occurring mild hearing loss, measured by pure-tone audiometry at the 1000 Hz frequency, does

not impact memory performance, nor does simulating a 23 dB hearing loss. Simulating a high-

mild 37 dB hearing loss, however, significantly decreased functioning on 5 of the 15 adult

battery WRAML2 subtests and on all composite memory domains.

The task requirements of the five affected subtests differ in some important ways from

the non-affected subtests. First, the five subtests are administered aurally and are only allowed

one administration; no cues are given as is the case with Story Memory, also administered once

aurally. Story Memory gives the examinee context about the story, which can act as a framework

for the material. On the other five aurally administered subtests, the examinee must be able to

hear the [rote] verbal information clearly in order to produce a correct answer. Secondly, the

context of each of the five affected subtests is very limited in syntax, semantics, and referential

relations (Daneman & Merikle, 1996). In contrast, it is notable that no participants, regardless of

hearing ability, struggled with Story Memory task demands, which is also aurally demanding but

rich in contextual meaning and allotted cues, and does not require a verbatim response. It has

been widely documented that linguistic context aids in speech comprehension (Akeroyd, 2008;

Kramer, Zakveld, & Houtgast, 2009; Ronnberg, 2003). If context is limited, cognitive resources

are required to improve understanding of the acoustical signal regardless, of perceptual clarity.

This is important with regard to hearing impairment, as the effortful hypothesis suggests that

cognitive resources are limited and can be highly impacted by environmental demands.

By significantly reducing the quality of the auditory signal, as was true for participants in

Group 3, both short-term and working memory tasks (tasks that involve greater complexity) were

compromised. The Sentence Memory subtest was notably impacted as well for Group 3.

Although, the participants were able to produce the gist of the information immediately after

each administration, they were unable to produce the information exactly as it was given,

particularly on sentences involving greater complexity.

Speech Comprehension

Although this study primarily focused on the effect of mild hearing loss on memory, it is

important to discuss linguistic and perceptual components in speech comprehension to ascertain

why the hearing loss participants performed as well as their hearing counterparts on all

WRAML2 subtest administrations, and why those in Group 3 did not. Pichora-Fuller (1998) and

her colleagues hypothesized that encoding auditory information into long-term memory is more

challenging when cognitive resources are used to improve speech understanding in degraded

acoustical signals. (Kramer et al., 2009; Pichora-Fuller et al, 1998). Within this literature,

cognitive capacity is often researched by using word-lists and/or short but meaningful sentences

in interfering noise. This helps researchers determine how challenging listening conditions can

influence communication. It has been well documented that individuals who classify themselves

as "hard of hearing" struggle with following lectures in large halls and have difficulty

participating in fast paced group discussions. It was anticipated that participants with mild

hearing loss would also struggle on WRAML2 subtests that involved auditory stimuli. This was not the case, however.

We can assume from the results of the present study that adults with naturally occurring mild hearing loss have adapted to, or compensated for, their loss over time by using the perceptual, linguistic, and cognitive cues that contribute to effective speech understanding (Pichora-Fuller et al., 1998). A large body of research has examined the interplay between perceptual cues (visual, auditory, and tactile stimuli), cognition, and how cognitive factors contribute to language understanding. Cognitive factors are especially important to consider with regards to language comprehension and hearing impairment.

Bottom-up processing is one's ability to process elementary perceptual units. In the case of auditory information, bottom-up processing refers to the "coding and transfer of the acoustic signals…into perceptual features such as loudness, pitch, and timbre" (Kramer et al., 2009, p.507). The speed of information processing, working memory, and use of linguistic context relate to top-down cognitive capacities. Top-down processing suggests that one's ability to process language starts with the larger chunks, i.e., concepts or words and works down to the finer details of decoding specific speech sounds. Top down processing is extremely important in deciphering muffled/distorted speech sounds, but top-down and bottom-up processing must work together for successful speech understanding (Ronnberg, 2003.) We might conclude from the results that individuals with naturally occurring hearing loss rely more on cognitive mechanisms for sufficient comprehension. The ability to generalize acoustical signals in phonetic categories could be one reason for good performance. Speech reading is another important aspect of

language decoding to discuss in terms of adaptation to hearing loss. Speech reading, though, is easier to perform with extended speech than with isolated words.

Research shows that both individual with normal hearing and those with hearing loss use speech reading to some extent. Speech reading is thought to be analogous to the more commonly used term, "lip reading," but lip reading implies that one only uses the movement of lips to help decipher nuances of comprehension ("Speechreading," n.d.). The term "speech reading" includes the act of reading lips, but it also involves taking visual cues from body language, facial expression, and sounds made by the cheek/throat in its more encompassing definition ("Speechreading," n.d.). For those with intact hearing, speech reading acts as an aid in everyday conversation, especially in noisy conditions, but it is critical that individuals with hearing loss develop this skill for successful speech comprehension. Interestingly, a study published in the journal of Speech, Language, and Hearing Research showed that speech reading proficiency in hearing loss individuals does not begin to advance from normal hearing individuals until after 14 years of age (Kyle, Campbell, Mohammad, Coleman, & MacSweeney, 2013). Therefore we can conclude that even the youngest hearing impaired participants in our study had at least four years to unconsciously practice and develop reliance on visual speech cues; those in the simulated groups did not have sufficient time to adapt to visual cues.

However, only 30% of information can be gleaned from speech reading. Even at the most advanced levels, an individual must be competent in language to extract meaning using speech reading (Ross, 1999). Many different speech sounds use similar physical movements of the lip, jaw, and tongue and are therefore difficult to differentiate visually. As such, an individual cannot rely on basic visual cues alone.

The environment is also critical for successful speech reading. As noted, speech reading is highly dependent on visual acuity and on the ability to assess rapid articulation. In ideal circumstances, the reader would be in an appropriately lighted room, directly facing the articulator without peripheral distraction. Such was the case with the current study – office lighting was sufficient, noise was kept to a minimum, and the examiner always faced the examinee regardless of assigned condition. Therefore, we can assume the environmental conditions were suitable for the speech reading process and that those with hearing impairment used their skills to successfully complete the memory tasks. If the WRAML2 battery was administered in noisy conditions, would the participants who had hearing loss have done as well as those with intact hearing? This might be an area of future research.

Interestingly, much of the recent research conducted in experimental audiology has focused on using sentence threshold tests to evaluate abilities in speech perception. While the test is easy to administer and more representative of everyday conversation than are rote memory tasks, a disadvantage of the speech threshold test is that the sentences employed as stimuli are too rich in contextual information (Bronkhorst & Wagner, 2002). As such, an individual can recognize inaudible/missed words because of transitional word identification. Bronkhorst and Wagner (2002) stipulated that the application of sentence tests do not help ascertain the role of phoneme perception and learning in speech comprehension.

Dahan and Mead (2010) argued that no speech sound is identical to any sound one has heard historically. In order to make sense of incoming acoustical signals, listeners rely on previously learned linguistic cues to categorize ambiguous sounds onto mental representations. It has been hypothesized that learning and adaptation occur via sublexical generalization (Dahan &

Mead, 2010). That is, basic units of speech, commonly known as phonemes, are the sublexical units of language that comprise the foundation of speech comprehension. Listeners are constantly adjusting their phonemic categories with incoming information to improve their ability to comprehend language.

In their investigation of perceptual learning and generalization, Dahan and Mead (2010) found that listeners who had prior exposure to distorted speech sounds were better than their untrained counterparts at subsequent word/sentence identification. They postulated that adaptation had occurred via sublexical generalization, even after only a few trials. Applying this concept to this study, we can make the assumption that individuals assigned to the high-simulated loss condition (37 dB) had not been able to adapt, or generalize, to the distorted words presented. Lower scores on the Verbal Learning subtest could be attributed to novel presentation of phonemic sound. That is, participants were unable to allocate sublexical information into the appropriate mental categories because the sounds were too novel for recognition. For example, "ice" is one word in the list of 16 words used to assess free immediate recall. Often a participant would hear "mice" instead of "ice" or another of the many rhyming words. This did not seem appear to be problematic with naturally occurring hearing loss, suggesting that categorical schemas have been appropriately adapted to sound distortion under favorable listening conditions.

Perhaps having had the chance to adapt to hearing loss over time by using environmental, contextual and linguistic cues, the hearing impaired participants performed as well as the hearing control group on all WRAML2 memory tests. The performance on memory tasks with low-mild simulated loss was also unremarkable. Comparing the performance of naturally occurring

hearing impairment to a high-mild simulated loss suggests that not enough time had lapsed to develop compensatory skills on verbally administered tasks. Hofman, Riswick, &Van Opstal, (1998) found that it could take several weeks for an individual to adapt to distorted sound and subsequently make correct judgments. Therefore, we can assume it would take at least a few weeks to make the adaptations necessary to mirror the performance of the naturally occurring mild hearing loss condition if no accommodations were made to the conditions.

Limitations

There are possible methodological concerns that might have impacted the findings of this study. First, the smaller sample sizes of each group may be viewed as inadequate and therefore results might be considered as misleading. However, the small sample sizes only impacted the statistical significance of conditions with small or moderate effect sizes. It can be argued that conditions with small or moderate effect sizes are practically and clinically irrelevant (Sink & Mvududu, 2010).

Another caveat to the study's conclusions are the methods by which hearing ability was measured. As stated in the introduction, there are distinctive types of hearing abilities including sensorineural, conductive, mixed, and neurological loss (Isaacson, 2003). Audiology tests can formally diagnose the type hearing loss by measuring the sounds that reach the inner ear through the ear canal via air waves and those that are transmitted through the back of the ear (skull) via bone conduction. A thorough hearing test conducted by an audiologist can take up to 30 minutes to administer in a sound-treated room. uHear, the eight-minute self-administered hearing screener used in this study, was unable to differentiate the type of hearing loss, using only the most basic frequency and decibel measurements to determine group placement. It is important to

note that conductive loss can look different than sensorineural loss in terms of language and other forms of cognitive development, particularly if the loss occurs early in childhood. This study did not account for these differences, nor was emphasis placed on assessing the differences between unilateral and bilateral hearing loss.

This screener was also used with generic headphones and was self-administered in a college campus building. Although many of the participants were alone within enclosed offices, noise outside the offices did not promote a quiet environment such as one would find in a soundproofed room. Therefore, participants may have missed pure-tone frequencies due to uncontrolled noise from outside their room. Further, the headphones used were not designed to mask interfering noise. Based on the test of aural frequencies, it was interesting to find that none of the participants, including those with hearing loss, had mild loss at the 2000 Hz frequency. This may indicate that the manufacturer designed these headphones to emphasize sound quality within this range, thereby skewing ones perception of incoming sound waves. Quality headphones with complete noise reduction capability would be recommended in further study.

Conclusion

The practical implications of this study are fairly clear. Individuals with mild hearing loss are not significantly dissimilar from their hearing counterparts in terms of memory performance. This suggests that an individual might compensate for mild hearing deficits by relying more heavily on cognitive resources and environmental cues. Clarity of hearing impairment determined by audiometric testing would be beneficial for studies of hearing loss, as would looking at hearing loss at all speech frequencies.

References

Akeroyd, M. A. (2008). Are individual differences in speech reception related to individual

differences in cognitive ability? A survey of twenty experimental studies with normal and

hearing-impaired adults. *International Journal of Audiology*, (47), S53 – S71.

Arlinger, S., Lunner, T., Lyxell, B., & Pichora-Fuller, M. K. (2009). The emergence of cognitive

hearing science. *Scandinavian Journal of Psychology*, (50), 371 – 384.

Atkinson, R., & Shiffren, R. (1968). Human Memory: A proposed system and its control

processes. In K.W. Spence & J. T. Spency (Eds.), *The psychology of learning and

motivation*, Vol 2. New York, NY: Academic Press.

Braden, J.P. (1990). Do deaf persons have a characteristic psychometric profile on the Wechsler

performance scales? *Journal of Psychoeducational Assessment, 8(4),* 518-526.

Bronkhorst, A.W., & Wagner, K. (2002). Evaluation of context effects in sentence recognition.

Journal of the Acoustical Society of America, 111(6), 2874-2886.

Carhart, R. (1946). Selection of Hearing Aids. *Archives of Otolaryngology, 44*, 1-18.

Dahan, D., & Mead, R. L. (2010). Context-conditioned generalization in adaptation to distorted

speech. *Journal of Experimental Psychology: Human Perception and Performance,

36*(3), 704-728.

Daneman, M., & Merikle, P. M. (1996). Working memory and language comprehension: A

meta-analysis. *Psychonomic Bulletin and Review, 4*(3), 422-433.

Domino, G., & Domino, M. (2006). *Psychological testing an introduction* (2nd Ed.). Cambridge,

United Kingdom: Cambridge University Press.

Double Hearing Protection: Two Devices for Best Hearing Safety. (n.d.). Retrieved from

      http://www.noisehelp.com/double-hearing-protection.html

Ericsson, K. A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review, 102*,

      211-245.

Giesbrecht, B. L. (2008). Evaluating the relationship among clinical measures of working

      memory (unpublished doctoral dissertation). George Fox University, Newberg, OR).

Hall, S. J. (2006). Comparison between memory test results among persons with Alzheimer's

      disease (unpublished doctoral dissertation). George Fox University, Newberg, OR.

Hallgren, M., Larsby, B., Lyxell, B., & Arlinger, S. (2005). Speech understanding in quiet and

      noise, with and without hearing aids. *International Journal of Audiology, 44(10)*, 574-

      583.

Hofman, P.M., Van Riswick, J.G., Van Opstal, A.J. (1998). Relearning sound localization with

      new ears. *Natural Neuroscience, 1(5),* 417-421.

Howieson, D. B., Dame, A., Camicioli, R., Sexton, G., Payami, H., & Kaye, J. A. (1997).

      Cognitive markers preceding Alzheimer's dementia in the healthy oldest old. *Journal of*

      the American Geriatric Society, 45(5), 584-589.

Issaacson, J. E., & Vora, N. M. (2003). Differential diagnosis of treatment of hearing loss.

      American Family Physician, 68, 1125-1132.

Issaacson, B., (2010). Hearing loss. *Medical Clinics of North America*, (94), 973-988.

Kahneman, D. (1973). *Attention and Effort.* Englewood, New Jersey: Prentice-Hall, Inc.

Kintsch, W., Healy, A.F., Hegarty, M., Pennington, B. F., & Salthouse, T. A. (1999). Models of

working memory: Eight questions and some general issues. In Miyake & Shah (Eds.),

Models of Working Memory, 412-441. Cambridge, UK: Cambridge University Press.

Kramer, S. E., Zakveld, A. A., & Houtgast, T. (2009). Measuring cognitive factors is speech

comprehension. The value of using the Text Reception Threshold test as a visual

equivalent of the SRT test. *Scandinavian Journal of Psychology, 50,* 507-515.

Kutz, J. (2015, March 26). Audiology Pure-Tone Testing. Retrieved from http://emedicine.

Medscape.com/article/1822962-overview

Kyle, F. E., Campbell, R., Mohammed, T., Coleman, M., & MacSweencey, M. (2013). Speech

reading development in deaf and hard of hearing children: Introducing the test of child

speech reading. *Journal of Speech, Language, and Hearing Research, 56*(2), 416-426.

Lin, F. R., Metter, E. J., O'Brien, R. J., Resnick, S. M., Zonderman, A. B., & Ferrucci, L. (2011).

Hearing loss and incident dementia. *JAMA Neurology, 68*(2), 214-220.

Maerlender, A. (2010). Short-term memory and auditory processing disorders: Concurrent

validity and clinical diagnostic markers. *Psychology in the Schools, 47*, 975-984.

Mild and Unilateral Hearing Loss in Children. (n.d.). Retrieved from

http://www.asha.org/aud/articles/hearlosschild.htm

Niedzielski, Humeniuk, Blaziak, & Gwizda, (2006). Intellectual efficiency of children with

unilateral hearing loss. *International Journal of Pediatric Otorhinolaryngology, 70,*

1529-1532.

Noise Induced Hearing Loss. (n.d.). Retrieved from http://american-hearing.org/disorders/

noise-induced-hearing-loss/

Paludetti, G., Conti, G., Di Nardo, W., De Corso, E., Rolesi, R., Picciotti, P.M., & Fetoni, A. R.
(2012). Infant hearing loss: from diagnosis to therapy. *Acta Otorhinolaryngologica Italica, 32,* 347-370.

Pichora-Fuller, M. (2006) Audition and cognition: What audiologists need to know about
listening. *Phonak, International Adult Conference.* Chicago, IL.

Pichora-Fuller, M., Johnson, C. E., & Roodenburg, K. E. J. (1998). The discrepancy between
hearing impairment and handicap in the elderly: Balancing transaction and interaction in
conversation. *Journal of Applied Communication Research, 26*, 99-119.

Piquado, T. P, Cousins, K. A.Q, Wingfield, A. & Miller, P. (2010). Effects of degraded sensory
input on memory for speech: Behavioral data and a test of biologically constrained
computational models. *Brain Research, 1365,* 48-65.

Plapinger, D. S., & Sikora, D. M. (1995). The use of standardized test batteries in assessing the
skill development of children with mild-to-moderate sensorineural hearing loss.
Language, Speech, and Hearing Services in Schools, 26, 39-44.

Preece, J. P., & Fowler, C. G. (1992). Relationship of pure-tone averages to speech reception
threshold for male and female speakers. *Journal of the American Academy of Audiology*,
3, 221-224.

Prevalence of Hearing Loss. (n.d.). The Better Hearing Institute. Retrieved from http://www.
betterhearing.org/hearingpedia/prevalence-hearing-loss

Rabbitt, P. (1968) Channel capacity, intelligibility, and immediate memory. *Quarterly Journal* of
Experimental Psychology, 20, 241-248.

Rabbitt, P. (1990) Mild hearing loss can cause apparent memory failures which increase with age

and reduce with IQ. *Acta Otolaryngologia, 476,* 167-176.

Ronnberg, J. (2003). Cognition in the hearing impaired and deaf as a bridge between signal and

dialogue: a framework and a model. *International Journal of Audiology, 42,* S68-S76.

Rose, N. S., Myerson, J., Roediger, H. L. III, & Hale, S. (2010). Similarities and Differences

between working memory and long-term memory: Evidence from the levels-of-

processing span task. *Journal of Experimental Psychology: Learning, Memory, and

Cognition*, 2, 471-483.

Shahidipour, Z., Geshani, A., Jafari, Z., Jalaie, S., & Khosravifard, E. (2013). Auditory memory

deficit in elderly people with hearing loss. *Iranian Journal of Otorhinolaryngology,

25*(72), 169-176.

Sheslow, D., & Adams, W. (2003). *Wide range assessment of memory and learning (2nd Ed.)*.

Lutz, FL: Wide Range.

Sink, C. A., & Mvududu, N. H. (2010). Statistical power, sampling, and effect sizes: Three keys

to research relevancy. *Counseling Outcome Research and Evaluation, 1*(2) 1-18.

Speechreading –e-Michigan Deaf and Hard of Hearing. (n.d.). Retrieved from http://www.

michdhh.org/assistive_devices/speechreading.html

Strauss, E., Sherman, E., & Spreen, O. (2006). *A compendium of neuropsychological tests:

Administration, norms, and commentary* (3rd ed.). Oxford, United Kingdom: Oxford

University Press.

Szudez, J., Ostevik A., Dziegilewshi, P., Robinson-Anagor, J., Gomaa, N., Hodgetts, B., & Ho, A. (2012). Can you hear me now? Validation of an iPod-based hearing loss screening test. *Journal of Otolaryngology – Head & Neck Surgery, 41*(1), S78-84.

Tun, P. A., Benichov, J. & Wingfield, A. (2010). Response latencies in auditory sentence comprehension: Effects of linguistic versus perceptual challenge. *Psychology and Aging, 25*(3), 730-735.

Uhlmann, R. F., Teri, L., Rees, T. S., Mozlowski, K. J., & Larson, E. B. (1989). Impact of mild to moderate hearing loss on mental status testing. Comparability of standard and written Mini-Mental State Examinations. *Journal of the American Geriatrics Society, 37(3*), 223-228.

Van Boxtel, C. E. M., Van Beijstervellt, P. J., Houx, L. J. C., Anteunis, J. F. M., Metsemakes, & Jolles, J. (2000). Mild hearing impairment can reduce verbal memory performance in a healthy adult population. *Journal of Clinical and Experimental Neuropsychology, 22*(1), 147-154.

Vernon M., (2005). Fifty years of research on the intelligence of deaf and head-of-hearing children: A review of literature and discussion of implications. *Journal of Deaf Studies and Deaf Education, 10*(3), 225-231.

Wang, J., Zupancic, S., Ray, C., Cordero, J., & Demke, J. (2014). Hearing test app useful for initial screening, original research shows. *The Hearing Journal, 67*(10), 32-35.

Wake, M., Hughes E. K., Poulakis Z., Collins C. & Rickards, F. W. (2004). Outcomes of children with mild-profound congenital hearing loss at 7 to 8 years: A population study. *Ear & Hearing, 25*(1), 1-7.

Wechsler, D. (2008). *Wechsler adult intelligence scale – fourth edition*. San Antonio, TX: The

Psychological Corporation.

Wingfield, A., Tun, P. A., & McCoy, S. L. (2005). Hearing loss in older adulthood: What is it

and how it interacts with cognitive performance. *Current Directions in Psychological

Science, 14*(3) 144-148.

Appendix A

Informed Consent Form

This document is intended to provide an explanation of the research study. If you have any questions or concerns once you have finished reading, please email Heather Deming at hpaige09@georgefox.edu or Kathleen Gathercoal, research advisor, at kgatherc@georgefox.edu.

The purpose of this study is to assess whether mild-to-moderate hearing loss affects different aspects of memory as measured by the Wide-Range Assessment for Learning and Memory – Second Edition (WRAML2), a standardized instrument often used in the field of psychology. There has been little research on whether hearing loss affects memory in an adult population within recent years and, of the research that has been done, few have utilized standardized psychological measures.

During the 120-minute session, you will be asked to complete a brief hearing screener (uHear) and participate in memory testing, which will be completed in one session at the Villa Academic Complex (VAC) located on the George Fox University Newberg campus. The testing proportion will be audio recorded to ensure scoring accuracy. Please read the following and sign on the bottom of the page if you agree to these stipulations:
I understand that the memory test takes approximately 90 minutes to administer. I am allowed short breaks as needed.

I volunteer to participate in the research project, but I can withdrawal from participation at any time. I will tell the examiner that I no longer wish to participate during testing or before testing has begun.

I understand that my evaluation results will remain completely confidential. I will not be asked for my name during the examination, but my age, sex, race and educational level are required. Instead of my name, I will be given a number code for identification.
I understand that audio recording is a necessary for scoring purposes and that Heather Deming will destroy it three-years after project completion.
I understand this research project has been reviewed and approved by the Institutional Review Board: Human Subjects Research Committee.

I will be been given a copy of this consent form to keep once I agree to participate, and have read and understand the research projects minimal risks and implications. Heather Deming answered my questions and helped to clarify anything that was confusing. Therefore, I agree to participate in this study.

_____   _____
Participant Signature   Date

Appendix B

Demographic Survey

NUMBER _____

DEMOGRAPHIC SURVEY

1. Are you male, female, transgender?

2. Provide your ethnicity:

3. Is English your first language?

4. Highest level of education you have completed?

5. Do you attend George Fox University?

6. Academic year (optional)

7. What is your religious affiliation?

8. What is your age (circle one)

     18 – 24

     25 – 29

     30 - 40

     41 – 45

Appendix C

Curriculum Vitae

Heather Paige-Deming
9 Wagon Wheel Place, Gillette, Wyoming
Phone: 503-710-4695
hpaige09@georgefox.edu

Education

Present   **Doctoral Student in Psychology Program**: George Fox University,
             Graduate Department of Clinical Psychology **(APA Accredited)**
             Newberg, OR
             Advisor: Kathleen Gathercoal, PhD
             Doctoral Dissertation: *Mild-to-Moderate Hearing Loss and Its Implications on*
             Memory Domains as Measured by the Wide Range Assessment of Memory and
             Learning – Second Edition (WRAML2)
             (Anticipated graduation: 2015)

2011   **Master of Arts, Clinical Psychology**: George Fox University,
             Graduate Department of Clinical Psychology **(APA Accredited)**, Newberg, OR

2007   **Bachelor of Science, Psychology**: Portland State University,
             Portland, OR

Supervised Clinical Experience

2013 – 2014 **Pre-Doctoral Internship**
             Campbell County Memory Hospital, Behavioral Health Services, Gillette,
             Wyoming
             (Psychologist Intern)
             Supervisors: William Heineke; Brooke England, PsyD
             Population: Children, Adolescents, Adults
             • Provide psychological services for children, adolescents, adults in inpatient
               and outpatient settings
             • Facilitate an inpatient group focusing on addiction; co-facilitate outpatient
               groups including Dialectical Behavioral Therapy for adolescents and
               resiliency for children between the ages of 5 and 12; group supervisor for the
               Summer Program (scheduled from June through July)
             • Administration of psychological evaluations to aid in diagnostic clarification
               and treatment; types of evaluations include, cognitive evaluations, system
               evaluations, pre-surgical evaluations, custody evaluations

- Two month rotation (1 day per week) at the Kids Clinic, a school-based pediatric clinic for Campbell County students, pre-kindergarten through 12 grade
- Consultation with health professionals and other staff for the purpose of treatment recommendations for both adults and children
- Act as an assessment supervisor for a Pre-Doctoral practicum student

2013 – 2014 **Pre-Internship**
School Based Behavioral Health, GFU Rural School District Consortium (Graduate Coordinator)
Supervisor: Elizabeth Hamilton, PhD
Population: Children, Adolescents, Adults
- Provided psychological services for children and adolescents
- Conducted comprehensive evaluations to assess for neurodevelopmental disorders, such as ADHD, autism spectrum, and
- Collaboration with a multidiscipline team including school staff, special education teachers and various mental health professionals
- Supervised practicum students within the Rural School District Consortium with the administration, scoring and interpretation of psychodiagnostic assessment
- Provided individual and group supervision for 2nd year graduate students in addition to organizing/co-facilitating monthly training didactics

2011 – 2012 **Practicum II**
Oregon State Hospital, Salem, Oregon (Psychological Trainee)
Supervisors: Robert Kruger, PsyD; Carlene Schultz, PsyD
Population: Severely mentally ill adult male inpatients
- Provided psychological services to adult males in a maximum-security inpatient hospital setting
- Consulted with a multi-disciplinary team regarding treatment regimens and assessment results for patients with psychiatric and neurological conditions
- Provided long-term individual psychotherapy with patients
- Facilitated psychoeducational groups, including effective communication, overcoming depression and social anxiety
- Administered comprehensive psychodiagnostic and neuropsychological assessments, including violence risk assessment, to patients and wrote integrative reports with diagnostic conceptualization and recommendations for treatment
- Participated in individual and group supervision
- Participated in monthly onsite didactic training, case presentations bi-monthly psychology meetings
- Facilitated a didactic presentation on malingering and presented it to staff and colleagues

- Presented four clinical cases to a supervisory clinical team
- Worked with a diverse population of male inpatients

2010 – 2011 **Practicum I**
North Clackamas School District (Student Therapist)
Supervisors: Patrick Joyce, EdS, NCSP; Fiorella Kassab, PhD
Population: Children, Adolescents
- Provided psychological services to children and adolescents between the ages of eight to thirteen in suburban elementary and middle schools
- Administered cognitive, adaptive and achievement assessments primarily to students suspected of having a learning disability and/or Attention Deficit Hyperactive Disorder, and to students on individualized education plans in order to update eligibility
- Scored assessments and wrote reports in order to help the school team determine a student's cognitive ability, academic standing, and adaptive functioning
- Provided long-term psychotherapy and intervention from a cognitive behavioral and behavioral approach to seventh and eighth grade students in a Supported Learning Curriculum Behavioral program, a program designed to provide support to students with behavioral difficulties, learning disabilities and/or poor academic functioning
- Provided individual play therapy with elementary school aged children
- Consultation and collaboration with teachers, coordinators, counselors, and parents regarding effective treatment planning
- Participated in individual and group supervision

2009 – 2010 **Pre-Practicum** (8/09 – 4/10)
George Fox University, Newberg, OR (Student Therapist)
Supervisors: Mary Peterson, PhD & Todd Hilmes, MA
Population: Undergraduate Student Volunteers
- Provided outpatient psychological services to male and female undergraduate students requesting counseling as part of course requirement
- Intake interviews, diagnosis, individual psychotherapy, and treatment planning
- Responsibilities included report writing, case presentations, and consultation with supervisors and teams three hours weekly
- Consultation with Graduate Department of Clinical Psychology faculty

---

Research Experience

2010 – 2014 **Doctoral Dissertation, Prelim Passed**: *Mild-to-Moderate Hearing Loss and Its Implications on Memory Domains as Measured by the Wide Range Assessment of Memory and Learning – Second Edition (WRAML2)*

Committee Members: Kathleen Gathercoal, PhD (Chair), Wayne Adams, PhD, Mark McMinn, PhD
Preliminary Oral Defense Completed (May, 2012)
Dissertation Defense Scheduled (May, 2015)

2010 – 2014 **Research Team Member**: George Fox University, Newberg, OR
Supervisor: Kathleen Gathercoal, PhD
- Participation on a research team that specializes in issues such as women issues, social phenomena, resiliency, and forensic assessment
- Bi-monthly meetings to discuss and collaborate on potential research topics, research design, statistical design, and methodology

2011 **Research Assistant**: George Fox University, Newberg, OR
Supervisor: Timothy Cooper, MA
- Administration and scoring of the Wide Range Intelligence Test (WRIT) as data collection for dissertation that looked at identifying whether relationships existed between levels of information literacy with intelligence and personality factors

2006 – 2007 **Research Team Member**: Portland State University, Portland, OR
Fall and Spring Semesters
Supervisor: Jacob Driesen, PhD
- Researched and extrapolated information about social anxiety disorder from published, peer-reviewed journals and applied it to Portland State University's continuing research.
- Conducted literature review on the neurological mechanisms of anxiety.
- Worked independently and within group settings.
- Administered the D-KEF to undergraduate participants of the department of psychology.

Teaching Assistance

2013 **Lifespan Development – Graduate Level Class:** George Fox University, Newberg, OR
- Co-facilitated group discussion
- Presented on twin infant development

2013 **Child Development – Undergraduate Level Class:** George Fox University, Newberg, OR
- Presented on twin prenatal and infant development to undergraduate students

Presentations

Deming, H., & Davis, S. (May, 2013). *Students against bullying.*

Presented at Providence Kid's Day Health Fair, Portland, OR

Paige-Deming, H., Lloyd, C., Kunze, K., Keith, T., Hovda, S., Kruszewski, A., & Gathercoal, K. (May, 2012). *Mentoring patterns for graduate and undergraduate students: A validation of the network-mentoring model.*
Presented at the annual meeting of the Oregon Psychological Association, Portland, OR.
Winner of the Oregon Psychological Association Competency in Education and Systems Award

Paige-Deming, H & Kruger, R. (December, 2011). *A look at malingering measures.*
Presented at Oregon State Hospital, Salem, OR

Relevant Work Experience

2008 – 2009   Community Integration Coach
Kaino's Home and Training Center, Redwood City, CA
Supervisor: Terry McManus, MA
Population: Ageing Adults with Developmental Disabilities
- Provided support to adults with developmental disabilities so they could participate in their community through a progressive, systematic program
- Independently coordinated daily activities for two autistic adults within the community to ensure the development of social skills, affect management, effective communication and safety
- Helped all residents learn to budget finances, cook, shop and provided counseling in health management and drug administration
- Demonstrated leadership, team-building and organizational skills
- Administered morning and evening medication to residents and recorded progress in a daily medication/medical log

---

Selected Professional Trainings

Apr 2015   **Certificate Program in Integrated Primary Care**
Fairleigh Dickinson University
Neftali Serrano, PsyD

Oct 2014   **Dialectical Behavioral Therapy**
Behavioral Tech, LLC
The Linehan Institute
Will be Completed May, 2015

Nov 2011   **Cross-Cultural Psychological Assessment**
George Fox University, Newberg, OR
Tedd Judd, PhD

Oct 2011   **Motivational Interviewing a Work in Progress; what it is, & Why to Use It**

George Fox University, Newberg, OR
Michael Fulop, PsyD

March 2011   **Child Custody Evaluations: Not for Everyone. Review of Recent APA Practice Guidelines**
George Fox University, Newberg, OR
Wendy Bourg Ransford, PhD

Feb 2011   **Neurobiological Effects of Trauma**
George Fox University, Newberg, OR
Anna Berardi, PhD

Oct 2010   **Primary Care Behavioral Health: Where Body, Mind (& Spirit) Meet**
George Fox University, Newberg, OR
Neftali Serrano, PhD

Oct 2010   **Best Practices in Multi-Cultural Assessment**
George Fox University, Newberg, OR
Eleanor Gil-Kashiwabara, PhD

July 2010   **Child and Adolescent Mood Disorders**
Stanford University, Palo Alto, CA
Manpreet Singh, MD

July 2010   **Creativity in Mood Disorders**
Terence Ketter, MD

July 2010   **Mood Disorders and Co-occurring Alcohol and Substance Use Disorders**
Anna Lembke, M.D.

July 2010   **Bipolar Disorder Treatment**
Po Wang, MD

July 2010   **Depression Treatment**
Charles DeBattista, MD

June 2010   **Outcomes Measure, Reimbursement, and the Future of Psychotherapy**
George Fox University, Newberg, OR
Jeb Brown, PhD

June 2010   **The Wechsler Memory Scale-4th Edition: Overview and Use with the Advanced Clinical Solutions for the Wechsler Scales**
George Fox University, Newberg, OR
James A. Holdnack, Ph.D.

June 2010   **Borderline Personality Disorder: Loving the Difficult Client**
              Cedar Hills Hospital, Portland, OR
              Christopher Corbett, PsyD

March 2010   **Current Guidelines for Working with Gay, Lesbian, and**
             Bisexual Clients; The New APA Practice Guidelines
              George Fox University, Newberg, OR
              Carol Carver, PhD

Relevant Course Work

Clinical Assessment   Personality Assessment
                                 Intellectual/Cognitive Assessment
                                 Child/Adolescent Assessment
                                 Neuropsychological Assessment
                                 Comprehensive Assessment

Research   Psychometrics
                                 Statistics
                                 Advanced Statistics/Research Design

Theory   Health Psychology
                                 Couples and Family Therapy
                                 Gender Issues
                                 Multicultural Issues in Therapy
                                 Biological Basic of Behavior
                                 Consultation, Education and Program Evaluation

---