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Effects of familiarity and presentation mode on auditory-visual speech recognition in adults with aphasia

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Effects of familiarity and presentation mode on auditory-visual speech recognition in adults with aphasia

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Abstract

Aphasia is a language disorder that has been acquired by about 2 million Americans, most commonly from stroke or traumatic brain injury. Research demonstrates that adults with aphasia can continue improving their speech and language for years after their stroke with therapy, which is contrary to traditional thought. Therefore, people with aphasia and their loved ones are searching for ways to continue speech and language improvements even after insurance runs out, and many are turning to technological therapy programs. However, there is little research on the skills people with aphasia need to benefit from these technological therapy programs. The current study reports on one of these skills, auditory visual speech perception. Six adults with aphasia completed a series of speech recognition tasks in four conditions: live familiar speaker, live unfamiliar speaker, recorded familiar speaker, and recorded unfamiliar speaker. Comparisons between these groups indicate that there was a statistically significant difference in performance between these groups. Results demonstrate that the live familiar condition is the most favorable condition, and that presentation mode (live v. recorded speech) may be more important than familiarity. Implications for daily life and treatment (including technological therapy programs) are discussed in the study.

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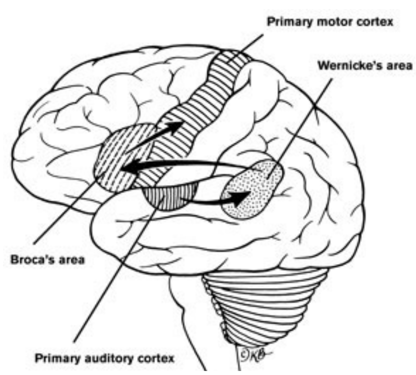
BACKGROUND

Aphasia

Aphasia is the most common neurological disorder, and there are at least one million people living with aphasia in the United States, with some researchers stating that the prevalence is even higher (NAA). Aphasia literally means “loss of language” in Greek, but in order to understand that loss of language, it is essential to understand language in the brain.

Language in most healthy adults is processed and produced in the left hemisphere of the brain. This process typically begins when sounds are received by the primary auditory cortex and then transmitted to Wernicke’s area, both of which are located in the temporal lobe of the brain. Wernicke’s area is responsible for adding meaning to this sound and comprehending language. Then, the signal is sent forward to Broca’s area, located in the frontal lobe, where the message is translated into a speech motor plan. Finally, this plan is carried out by the primary motor cortex for language production.



When the tissue in any of these areas of the brain is damaged or dies, a person’s ability to produce or understand language can be affected, which is then called aphasia. Aphasia is usually acquired suddenly, most commonly as a result of a stroke or, less frequently, as a result of Traumatic Brain Injury. However, aphasia can also be acquired over time from brain tumors, infections, or dementia.

The type and severity of aphasia depends on the location and extent of brain damage, so each person with aphasia has a unique set of symptoms to his or her injury. For example, if someone had a stroke that cut off blood supply to Wernicke’s area, he or she may have trouble with language comprehension, whereas if Broca’s area was affected by the stroke or injury, they may have difficulty producing language.

In very simple terms, these examples point to the two broad types of aphasia: fluent and non-fluent. Fluent aphasia is characterized by impaired receptive language abilities and utterances greater than four words. These utterances may sound like typical speech in prosody and length, but they often lack contentives. Non-fluent aphasia is characterized by utterances of less than four words, which can contain large pauses and “blocks.” However, these short utterances may contain more meaningful words, such as nouns and verbs. Clearly, the effects of aphasia are significant and varied among different types.

Aphasia is often just one result of brain damage. People with aphasia (abbreviated as PWA in this study) also can have many other symptoms from their injury, which can include mobility problems and left-sided paresis or paralysis. Most of these symptoms benefit from treatment, so it is often difficult to choose how to allocate time and resources when working toward recovery. Though some people may have partial spontaneous recovery from aphasia, speech-language pathology treatment is beneficial for recovering any possible language abilities and compensating for deficits in order to facilitate communication.

Treatment and Technology

It was traditionally taught that there was a critical window of one to two years post-stroke or injury for any improvements to be made from therapy (NIDCD). However, research demonstrates that significant improvements can be made even in the chronic stage of aphasia, many years post-stroke or injury (Aftonomos, et.al). This is a very hopeful discovery, but the unfortunate reality is that insurance coverage often runs out before people are ready to leave therapy, and many people cannot afford to pay for treatment on their own (American Stroke Assoc.).

In an attempt to advise people on how to keep improving after insurance runs out, there are many tip sheets and resources that suggest free services, research trials, and practicing at home. One of the top five suggestions to continue improving is using technological therapy programs, such as computer-based software programs or apps to continue independent speech and language practice at home (Cameron & Wright, 2009). There are a wide variety of technological therapy programs for people with aphasia, and they vary in treatment focus, price, and quality.

There has been interest in using technology in home treatment plans since the early days of home computers. Petheram (1992) conducted a study on therapists' attitudes to using computers for home-based treatment. Petheram surveyed 572 speech-language pathologists who worked with PWA and found that there was widespread interest in using computers in home-based therapy. The interest in using technology in therapy has only grown since computers have increased in prevalence and improved in quality. In 2004, Petheram continued his research in this area in a special edition of the journal Aphasiology dedicated to computers and aphasia. It focused on cueing, efficacy of computer mediated therapy, and benefits of the information age for PWA. There is a growing body of research on specific computer treatment programs; however, there are fewer studies on the fundamental speech and language elements of these computer-based systems.

Technological Therapy Programs

Technological therapy programs have mostly focused on specific skills including naming, sentence comprehension (Crerar et al., 1996), sentence construction (Linebarger et al., 2001), spelling (Mortley et al., 2001), and conversational scripts (Cherney et al. 2008). In addition to these computer-based programs, there has been a huge influx of apps created for people with aphasia. These apps are ever increasing in popularity, but it is very difficult to find any studies examining the efficacy of apps. The majority of the technological treatment systems that have been assessed in studies are computer-based and focus on naming abilities (e.g. Abad et al., 2013; Palmer et al., 2012, Raymer et al., 2006; Laganaro et al., 2006; Doesborgh et al., 2004; Pluta, A., 2009). Several of these studies indicate the effectiveness of computer-based training for anomia.

One of the most recent studies by Abad et al. (2013), discusses an on-line system that behaves as a virtual therapist by using automatic word naming recognition to perform word-training exercises for adults with aphasia. Though each participants' program is set up by a SLP (speech language pathologist), the actual training is done via a computer system. The study examined speech recognition correlations for 16 adults with aphasia by comparing human ratings of their speech productions versus computer ratings, and found highly correlated global word naming scores. However, they did not examine the actual efficacy for patients. The authors plan to explore that through "opinion questionnaires" for the SLPs and PWA. Though the information on speech recognition correlation is a useful first step, efficacy data will be necessary to determine the program's usefulness in treatment.

Another useful study focusing on naming was assessed in a pilot single-blinded randomized clinical trial by Palmer et. al (2012). Thirty-four participants with aphasia were allocated randomly to a control group or computer treatment group. After the treatment group completed 25 hours of independent practice, they improved 19.8% more than the control group who was only exposed to everyday language activity. This demonstrates that a computer treatment program is in fact better than no treatment at all.

In a study that examines efficacy of script training, Cherney et. al (2008) developed a computerized script training program for people with chronic aphasia. Three adults with aphasia completed nine weeks of computer script training, accompanied by weekly meetings with a speech-language pathologist. All three participants improved on every measure for the scripts, and two patients gained more than five points on the Aphasia Quotient of the Western Aphasia Battery (WAB AQ; citation here), a measure of severity of aphasia. This indicates that under specific conditions, computerized script training can be an effective intervention.

Archibald, Orange, and Jamison (2009) studied a more comprehensive rather than specific computer-based language therapy program in a pilot study. Eight PWA used a comprehensive computerized treatment program for at least one hour a week for an average of fifteen weeks, and most participants chose to have a trained person present to assist solely with computer operation. Participants improved in auditory comprehension with significance, naming and spontaneous speech approaching significance, but there were no significant improvements found in repetition, reading and writing, or the WAB AQ. However, though their scores did not reach significance, six of the eight participants did improve in their WAB AQ. This study demonstrates that a general computer-based language therapy program can be an effective intervention for certain aspects, and it will be interesting to see the full results.

The previously discussed studies examine computer treatment programs, but there are very few studies that demonstrate which variables in these programs are most important, and even fewer studies that discuss the fundamental skills needed for successful use of these programs.

One study that examines a component of computer programs was conducted by Choe and Stanton (2011) in which they specifically compared auditory cues and auditory-visual cues in naming tasks. Two individuals with aphasia practiced naming tasks in the auditory-only and auditory-visual conditions. They practiced ten names with video clips and ten names with sound files. Though both individuals improved in both conditions, improvement was more rapid, consistent, and significant in the auditory-visual condition. A qualitative analysis of utterances also suggested that the auditory-visual condition was favorable for computerized aphasia treatment. The current study expanded upon this finding to investigate an even more basic skill required for successful utilization of computer training programs: speech recognition.

Speech Recognition in Adults with Aphasia

Adults with aphasia may have difficulties speaking, listening, reading, and writing, but there are certain variables that maximize communication. Previous studies, such as Choe and Stanton (2011) suggest that one factor that may be beneficial to adults with aphasia is visual cues for spoken language. There is some research on auditory-visual cues in adults with aphasia, but there is even more literature about this in another clinical population, adults with hearing loss. In a study on auditory-visual speech perception, Bernstein, Demorest, and Tucker (2006) concluded that visual speech perception is more accurate than previous research suggests, especially in clinical populations such as adults with hearing loss.

The current study fits into a greater body of literature about auditory-visual speech recognition in adults with aphasia. In a study that looked at the benefits of visual cues to speech, Youse, Cienkowski, and Coelho (2004) studied the identification of auditory, visual, and auditory-visual tokens and the presence of the McGurk effect in an individual with aphasia. One individual with aphasia, and two non-brain injured participants repeated what was said in auditory, visual, and auditory-visual conditions. The adult with aphasia performed best in the auditory-visual condition and lowest in the visual-only condition. However, the results did not show significant improvement in the bimodal condition since results were near ceiling, and there was an incongruent McGurk effect. The current study will take this ceiling effect into consideration when choosing stimuli. Non-meaningful CV syllables, biased response pattern, and the nature of the task may have played a role in the adult with aphasia's performance. However, the study by Youse et al. (2004) does support the idea that visual cues may benefit adults with aphasia.

Shindo, Kimitaka, and Tanaka (1991) also studied auditory-visual speech recognition by examining lip reading ability in adults with word deafness, or auditory agnosia. Four patients completed neurophysiological tests of auditory perception, auditory comprehension, and lip reading. The results showed that lip reading plus listening was better than lip reading only or listening only. The authors assert that this may indicate that lip reading is an important tool for improving comprehension of speech for adults with word deafness or auditory agnosia. This study indicates the significance of auditory-visual stimuli as opposed to auditory or visual only for adults with word deafness or auditory agnosia.

These studies, along with Choe and Stanton's (2011) study specifically about auditory-visual speech recognition in computer treatment programs, confirm that auditory-visual cues are important for improving speech recognition in adults with aphasia. The current study will utilize auditory-visual cues to investigate other less-researched variables that may affect performance on computer treatment programs and general communication for adults with aphasia: familiarity and live v. recorded speech.

Familiarity and Speech Recognition

Though there are few studies on familiarity and speech recognition in adults with aphasia, there is both clinical and empirical evidence that familiarity is intact and it does impact various aspects of communication in PWA. Technological therapy programs, if they do include visual cues such as a face, are usually unfamiliar or animated faces. This raises the question: do PWA perform better with familiar or unfamiliar speakers, and how should that influence technological therapy programs?

Flude, Ellis, and Kay (1989) studied the storage of names and semantic information of familiar people in an adult with anomic aphasia. One participant completed tests on face decision, sex decision, emotional expression matching, facial recognition, and facial categorization. He could discriminate between familiar and unfamiliar people; his face recognition units and person identity nodes were intact, but his spoken name retrieval was severely impaired. Since the study indicates that facial recognition is intact in adults with aphasia, familiarity is an element of communication that could impact speech recognition.

Dressler, Buder, and Cannito (2009) studied prosodic tempo in speakers with aphasia during conversational repairs. They acoustically analyzed conversations of 3 adults with aphasia each with a familiar and an unfamiliar speaker. The results of the study were that normal speakers changed prosodic tempo based on the type of conversational repair, whereas speakers with aphasia changed tempo based on partner familiarity, which demonstrates that familiarity may be particularly important for adults with aphasia compared to normal adults. This study demonstrates that adults with aphasia may perform better with familiar partners because with unfamiliar people, they feel less comfortable asking for help and fear looking bad.

Stimley and Noll's (1994) earlier study of the impact of familiarity on verbal abilities of people with aphasia found results contradictory to that of Dressler, Buder, and Cannito (2009). Eight adults with aphasia completed the verbal subtests of the Porch Index of Communicative Abilities with familiar or unfamiliar examiners. The adults with aphasia performed significantly better with the unfamiliar examiners. Since these results are opposite of subsequent studies, it is clear that more research must be completed in the area of familiarity.

Though familiarity and speech recognition in adults with aphasia have not been studied extensively, studies by Flude, Ellis, and Kay (1989), Stimley and Noll (1994), and Dressler, Buder, and Cannito (2009) indicate that familiarity is intact in adults with aphasia. It may be particularly important for adults with aphasia, and familiarity may increase or decrease their performance in some aspects of communication. The conflicting data posed by these papers is a motivation for the current study.

Presentation Mode and Speech Recognition

In addition to familiarity, presentation mode of live versus recorded speech could also affect speech recognition of adults with aphasia. In computer treatment programs, the speech is usually recorded, but there is little research on how that impacts speech recognition for adults with aphasia.

Presentation mode has been studied peripherally to other investigations. For example, Haley et al. (2011) examined the psychometric properties of a new intelligibility test for adults with aphasia or apraxia of speech, while also studying live models versus pre-recorded models. Twenty-three speakers with aphasia and 20 normal speakers took a new single-word intelligibility test, speech samples were recorded, and intelligibility testing was performed. Though there was no significant difference between live and recorded speech, some of the 23 participants showed an advantage in the live elicitation. This may indicate that live speech is somewhat beneficial for adults with aphasia.

Summary

Taken together, past work on auditory-visual speech recognition in adults with aphasia suggests the visual cues to spoken language could benefit adults with aphasia, and familiarity and presentation mode may be related to performance on tests of speech recognition. Therefore, this study examines two fundamental research questions: Does familiarity affect auditory-visual speech recognition in adults with aphasia? Does presentation mode affect auditory-visual speech recognition in adults with aphasia?

Based on the study by Haley et al., the expected result is that adults with aphasia will perform better with a live speaker as compared to a recorded speaker. Flude, et al. (1989) and Dressler et al. (2009) indicated that familiarity is intact in adults with aphasia, and familiarity may be particularly important for adults with aphasia. Since Stimley and Noll (1994) found contradictory results, it is expected that there will be a difference between a familiar and unfamiliar speaker.

Purpose

The purpose of this study was to determine the effects of familiarity (familiar vs. unfamiliar talker) and presentation mode (live vs. recorded speech) on auditory-visual speech recognition in adults with aphasia. It was anticipated that participants would perform best with a live familiar talker.

Methodology

In this study, participants completed a series of tests designed to learn what makes it more difficult or easier for people with aphasia (PWA) to listen and understand spoken language.

Participants

The participants for this study were recruited from aphasia support groups in the Indianapolis area. The study included 6 participants with aphasia and their caregivers. Four of the participants were male and two participants were female. The range of ages was 44 to 70, and the participants had high school or some college education. The majority of the participants acquired aphasia from a stroke, but one participant acquired aphasia from an infection. The participants were all in the chronic phase of aphasia with a post-stroke range from six months to six years. The WAB was utilized to assess their repetition scores, type of aphasia, and AQ. The repetition information is useful since the experimental tasks require repetition, and the type of aphasia and AQ provide valuable information about each person's aphasia. See Table 1 for a summary of participant information.

Table 1. Participant Information

	Age	Gender	Education	Etiology	Duration of Aphasia	WAB-R Repetition Score	Type of Aphasia	WAB - R Aphasia Quotient (severity)
M01	44	M	Some College	encephalitis	6y	33	Conduction	74.5 moderate
F01	57	F	High School	stroke	3 y	46	Conduction	75.1 mild
M02	70	M	High School	stroke	6 mo	54	Broca's	68.5 moderate
M03	68	M	High School	stroke (2)	2 y 9 mo	58	Broca's	59.8 moderate
M04	55	M	High School	stroke	4 y 7 mo	48	Broca's	51.7 moderate
F02	64	F	High School	stroke	1 y 1 mo	82	Transcortical Motor	72.4 moderate

Procedure

This study was completed by participants in two visits to the Speech Research Lab at Butler University. During the first visit, the caregivers were introduced to the study through a statement of informed consent. Next, the caregiver was videotaped reading sentences that were used to create the stimuli for the familiar/recorded test of speech recognition.

The caregiver and the adult with aphasia returned for a second visit to the lab. Each participant with aphasia was introduced to the study through a statement of informed consent. Then they completed the screening tests listed in Table 2, designed to gather background information. The screening tests provide a general baseline of perceptual and cognitive skills. In the final screening test, patients completed the WAB, an assessment that diagnosed the type and severity of aphasia. This revealed information about how their brain processes language, including speech recognition.

Table 2: Background tests for adults with aphasia

Screening Measure	Screening Activities and Materials
History	A personal history of aphasia and other background variables such as level of education was taken through a detailed interview.
Vision Test	The Lea Symbols Chart was used to test age-appropriate vision.
Hearing test	Pure tone air conduction thresholds were taken to ensure age-appropriate hearing.
Reaction time test	Auditory, visual, and auditory-visual response times (to basic stimuli such as lights and tones) were taken to establish a baseline response time for motor response.
Short-term memory test	A visual-aural digit span test was given to evaluate overall short-term memory

	skills.
Diagnostic Examination of Aphasia	The Western Aphasia Battery was administered in order to obtain information on repetition and type and severity of aphasia.

As seen in Table 3, all participants scored within functional limits for both vision and hearing, which meant they qualified to complete the tasks of the study. Their response times varied from 0.359 to 1.462 s. The median visual digit span was 1 digit, and the median auditory digit span was 2.5. Participants performed better on the auditory digit span task, an important skill since the speech recognition tests required auditory working memory.

Table 3: Screening Measures

	Visual Acuity	Right Ear PTA (dB)	Left Ear PTA (dB)	Response Time	Visual Digit Span	Auditory Digit Span
M01	20/25	0	0	0.469	7	3
F01	20/25	20 (aided)	61	0.641	2	2
M02	20/25	5	8	0.485	0	6
M03	20/25	10	10	0.359	3	2
M04	20/25	15	15	0.464	0	0
F02	20/25	17	7	1.462	0	3

After these screening measures were completed, the participants with aphasia completed the speech recognition tests in an audiometric sound booth. Participants completed a speech recognition test in each of four listening conditions displayed in Table 4. The stimuli, described more in depth below, were the Central Institute for the Deaf sentences (CID; Davis & Silverman, 1970) and NU-6 words (Wilson et al, 1990). Participants were seated about 50 inches from a computer monitor for the recorded conditions and about 50 inches from the talker's face in the live condition. All recordings and live tasks were completed in the same audiometric booth with the same background, and the relative size of the face of the talker was consistent in the recordings and in the live condition.

Table 4: Study design: test materials by presentation mode.

	Live voice	**Recorded voice**
Familiar speaker (Caregiver)	• Caregiver reads NU-6 words – Set A • Caregiver reads CID sentences – Set A	• Recording of caregiver reading NU-6 words – Set B • Recording of caregiver reading CID sentences – Set B
Unfamiliar speaker (Researcher)	• Researcher reads NU-6 words – Set C • Researcher reads CID sentences – Set C	• NU-6 words from Butler Auditory-Visual corpus – Set D (Richie, Warburton, and Carter 2009) • CID sentences from Butler Auditory-Visual corpus –Set D (Richie, Warburton, and Carter 2009)

Stimuli

All stimuli were presented in an auditory-visual condition, because literature indicates that is the most favorable condition for speech recognition in PWA (Youse et. al, 2004; Shindo et. al, 1991). Speech recognition was tested at the word level and the sentence level. These two types of materials – words and sentences – enabled PWA to demonstrate their speech recognition over two levels of linguistic complexity. The sentence level is more difficult, which avoids the ceiling effect of participants getting one hundred percent correct in all conditions. The sentence materials were CID sentences, balanced sets of ten sentences (Davis & Silverman, 1970). The word materials are NU-6 words, sets of 50 words (Wilson et. al, 1990). These materials are representative of everyday speech, the vocabulary is appropriate, they are not too abstract, and phonetic loading is avoided. In each test, the participant with aphasia was presented with sentences or words, and their task was to repeat each stimulus aloud.

Outcome Measures

To determine each participants' individual speech recognition abilities, each test was scored in terms of percent correct word recognition (0.00-1.00). Successfully repeating a high percentage of words demonstrates a high level of speech recognition.

Results

In response to the question, "What is the effect of presentation mode and familiarity on auditory-visual speech recognition in adults with aphasia?" performance should be measured in each condition. Tables 5 and 6 demonstrate performance in all conditions on word tasks and sentence tasks. Performance varied by task, and there were also clear differences in participants based on the type and severity of aphasia. Almost all of the participants performed better on words than on sentences.

Table 5: Performance of each participant on tasks of speech recognition with words

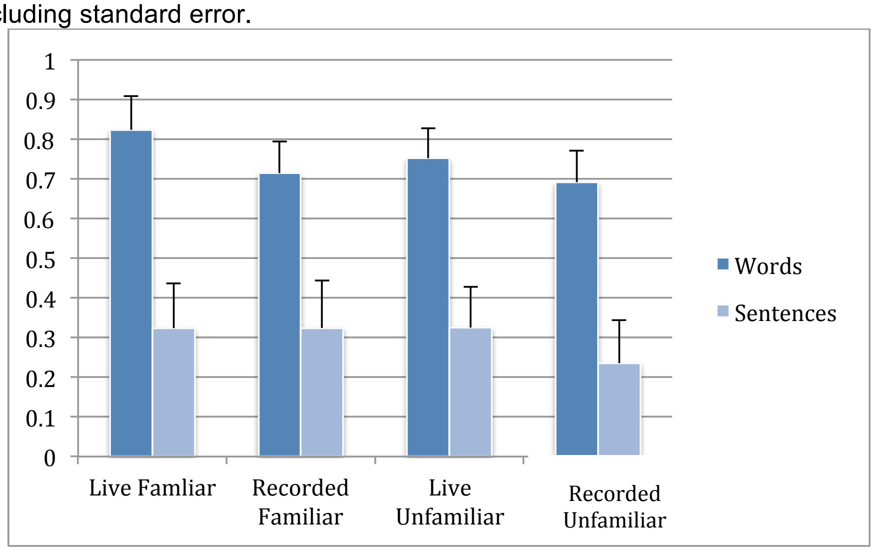
	Live Familiar Words	Recorded Familiar Words	Live Unfamiliar Words	Recorded Unfamiliar words
M01	0.78	0.66	0.74	0.58
F01	0.96	0.86	0.88	0.82
M02	0.52	0.46	0.48	0.48
M03	0.86	0.60	0.66	0.58
M04	1.00	1.00	1.00	1.00
F02	0.98	0.94	0.94	0.80
Average	0.85	0.75	0.78	0.71

Table 6: Performance of each participant on tasks of speech recognition with sentences

	Live Familiar Sentences	Recorded Familiar Sentences	Live Unfamiliar Sentences	Recorded Unfamiliar Sentences
M01	0.21	0.27	0.25	0.15
F01	0.27	0.28	0.34	0.19
M02	0.40	0.36	0.18	0.15
M03	0.34	0.45	0.64	0.44
M04	0.32	0.32	0.33	0.24
F02	0.96	0.93	0.96	0.83
Average	0.42	0.44	0.45	0.33

When these tables are combined (see Figure 1), there is a notable pattern in performance for most of the participants. The participants appeared to do better in the live familiar condition than in any of the other conditions. Also notable is that there was a higher standard error for sentences than for words. Sentences were shown to be much more difficult to repeat than words, so this amount of error is not unexpected. In order to further examine the relationship between variables and performance, a statistical analysis was completed.

Figure 1: Average performance of each participant on tasks of speech recognition, including standard error.



Data Analysis

After investigating performance, the two research questions were tested using a parametric analysis of variance, the two-way repeated measures ANOVA, with the criterion set at $p < 0.05$. Non-parametric analyses were considered because of the small sample size, but because of the relative normality of the data and a small clinical population in general, a parametric analysis was chosen. The two-way repeated measures ANOVA was selected because it measures differences between groups with a continuous dependent variable, such as performance measured from zero to one and repeated measures.

It is notable that, similar to most real-world information, the data did violate some assumptions of the ANOVA. Participants volunteered for the study from an aphasia community instead of being selected randomly. Also, adults with aphasia are a clinical population, and each individual with aphasia is different. Therefore, even if the sample had been collected randomly, it would be difficult to say that it is truly representative of the entire population. Instead, results can be interpreted as representative of the individuals in the study and suggestive of the population in general. As an exploratory study, this thesis will hopefully lead to larger, more in-depth randomized studies of these topics.

Table 7 presents an analysis of whether or not there is a difference in performance between the four conditions. At a significance level of $p < 0.05$, there is a statistically significant difference between the four conditions. This means that there is a relationship between the condition in which people with aphasia are presented speech and their performance on tests of speech recognition. The highest level of significance was met in the presentation mode category in sentences, and the only category that was not statistically significant was familiarity within sentences tasks. This indicates that the largest difference in performance was in live versus recorded sentences.

Table 7. Significance Results for Two Variables

	Significance (words)	Significance (sentences)
Familiarity	$p < 0.026$ *	$p < 0.498$
Presentation Mode	$p < 0.023$ *	$p < 0.003$ *

* = Significant at the 0.05 level

To determine the differences between conditions, conditions were paired up again and tested for significance with correction. In order to avoid a Type 1, or false positive, error, the *p* value was set using the Bonferroni correction (dividing the critical *p* value of 0.05 by the number of comparisons being made). When adjusted using the Bonferroni correction to counteract the problem of multiple comparisons, the three significant conditions still met the level of significance.

This data shows that there is a significant difference between scores in each of four conditions. Participants performed differently in the familiar condition than in the unfamiliar condition, and they also performed differently in the live condition versus recorded condition. As seen in Figure 1, participants performed best in the live familiar condition. Further than this, it is important to note that presentation mode may be even more important than familiarity. In the more difficult task of repeating sentences, the differences in performance in conditions of live versus familiar speech were even more pronounced ($p < 0.003$), but familiarity no longer reached the level of significance. This demonstrates that in harder tasks, presentation mode was more important and familiarity was less important. Therefore, live presentation mode may be more helpful for PWA than a familiar speaker.

Further testing must be done to establish what is the cause of the relationships seen in the data. For instance, it should be noted that the participants' ability to repeat in general varied widely, as measured in screening tasks by the WAB. It should be investigated whether or not people's skills in repetition in general impacted the findings seen in this study.

In order to test the relationship between several cognitive skills and performance on the tasks of speech recognition, Pearson's Correlation was completed. Using the screening tests, correlations were measured for memory (auditory and visual digit span) and repetition tasks. In the words tasks (see Table 8), it was found that only one interaction correlated with significance: auditory digit span compared to live familiar speech. This may demonstrate that memory has some impact on performance in the live familiar condition.

Table 8: Correlation and Significance within Word Task

		Live Familiar	Recorded Familiar	Live Unfamiliar	Recorded Unfamiliar
Visual Digit Span	Pearson Correlation	-0.095	-0.307	-0.179	-0.401
	Sig. (2-tailed)	0.858	0.554	0.735	0.431
Auditory Digit Span	Pearson Correlation	-0.873 *	-0.753	-0.8	-0.801
	Sig. (2-tailed)	0.023	0.084	0.056	0.055
WAB - R Repetition Score	Pearson Correlation	0.225	0.24	0.171	0.132
	Sig. (2-tailed)	0.669	0.647	0.746	0.803

* = Correlation is significant at the 0.05 level

In the sentence tasks, significant correlations (greater than or equal to 0.80) were found between repetition and performance in all four conditions. Sentence tasks require a higher cognitive load, and so it is not surprising that each participant's ability to repeat impacted performance on tasks. However, since this high correlation between ability to repeat and performance on speech recognition tests was seen consistently in all four conditions in the sentence tasks, repetition skills do not explain the differences between the four conditions.

Taken as a whole, this correlation data demonstrates that the effects seen in this study cannot be explained by the factors of memory or repetition ability. In summary, these statistical analyses demonstrate that there is a statistically significant difference between the four conditions, and the live familiar condition appears to be most favorable for speech recognition for PWA.

Discussion

The above results provide experimental data that confirms that there are conditions in which PWA are able to listen and perceive language more effectively. It is important for family members, healthcare providers, and other people who interact with PWA to know that the live, familiar condition is the most favorable for PWA. This is useful data in daily life, but it is even more important when referring to one of the top five tips for helping adults with aphasia continue to make improvements in speech and language after insurance runs out: computer-based therapy programs.

Most computer therapy programs utilize a “virtual therapist” or some sort of recorded talker or voice. Speech perception is required for PWA to benefit from this therapy. Since the results of this study indicate that live familiar talkers are the most helpful for PWA, it is advantageous to consider how to incorporate a live, familiar person into this technological therapy. This could include having a spouse or caregiver sit with the PWA and work on therapy activities with them. Though there may be time or availability barriers to this possibility, improvement could be worth surmounting these difficulties. Also, since the study suggested that the presentation mode of live speech is perhaps even more important than familiarity, avenues could be explored for volunteers to work with PWA on these computer programs.

Future Research

As noted above, there are some studies on the efficacy of computer-based training programs, but there are very few studies on the fundamental skills needed to benefit from these therapy programs. Speech recognition is just one skill that is needed, so it would be beneficial for research to be conducted on a broader range of speech and language skills as related to technological therapy alternatives.

Conclusion

In conclusion, PWA performed best in speech recognition tasks when listening to a live, familiar speaker. According to the study, the presentation mode of stimuli is especially important when working with PWA, and measures may be taken to utilize this information and apply it to computer-based therapy methods. Further research should be conducted on other ways to adapt computer-based therapy methods to effectively meet the needs of PWA and their families. As professionals, it is imperative that we examine current barriers and solutions to problems such as limited insurance coverage. However, we also must go back and research the fundamental skills needed to benefit from creative solutions such as computer-based therapy.

References

Abad, A., Pompili, A., Costa, A., Trancoso, I., Fonseca, J., Leal, G., & ... Martins, I. P. (2013). Automatic word naming recognition for an on-line aphasia treatment system. *Computer Speech & Language*, *27*(6), 1235-1248.

Aftonomos, L. B., Appelbaum, J. S., & Steele, R. D. (1999). Improving Outcomes for Persons With Aphasia in Advanced Community-Based Treatment Programs. *Stroke, 30*(7), 1370-1379.

Aphasia Fact sheet - National Aphasia Association. (n.d.). Retrieved January 15, 2016, from http://www.aphasia.org/aphasia-resources/aphasia-factsheet/

Archibald, L. M., Orange, J. B., & Jamieson, D. J. (2009). Implementation of computer-based language therapy in aphasia. *Therapeutic Advances in Neurological Disorders, 2*(5), 299-311.

Bernstein, L. E., Demorest, M. E., & Tucker, P. E. (2000). Speech perception without hearing. *Perception & Psychophysics, 62*(2), 233-252.

Brownell, H., Hoyte, K., Piquado, T., & Wingfield, A. (2012). Analytic Methods for Single Subject and Small Sample Aphasia Research: Some Illustrations and a Discussion. In *The Handbook of Neuropsychology of Language* (1st ed., pp. 595-618). Blackwell Publishing.

Brownell, H., Pincus, D., Blum, A., Rehak, A., & Winner, E. (1997). The Effects of Right-Hemisphere Brain Damage on Patients' Use of Terms of Personal Reference. *Brain and Language,* 60-79.

Cherney, L., Halper, A., Holland, A., & Cole, R. (2008). Computerized Script Training For Aphasia: Preliminary Results. *American Journal of Speech-Language Pathology,* 19-34.

Choe, Y., & Stanton, K. (2011). The effect of visual cues provided by computerized aphasia treatment. *Aphasiology, 25*(9), 983-997.

Davis, H., & Silverman, S. (1970). Hearing and deafness (3rd ed.). NY: Holt, Rinehart, and Winston.

Doesborgh, S. J. (2003). Effects of Semantic Treatment on Verbal Communication and Linguistic Processing in Aphasia After Stroke: A Randomized Controlled Trial. *Stroke, 35*(1), 141-146.

Dressler, R., Buder, E., & Cannito, M. (2009). Rhythmic patterns during conversational repairs in speakers with aphasia. *Aphasiology*, 23(6), 731-748.

Flude, B., Ellis, A., & Kay, J. (1989). Face processing and name retrieval in an anomic aphasic: Names are stored separately from semantic information about familiar people. *Brain and Cognition,* 11, 60-72.

Haley, K., Roth, H., Grindstaff, E., & Jacks, A. (2011). Computer-mediated assessment of intelligibility in aphasia and apraxia of speech. *Aphasiology*, *25*(12), 1600-1620.

Helfer, K. S. (1998). Auditory and auditory-visual recognition of clear and conversational speech by older adults. *Journal of the American Academy of Audiology, 9*(3), 234-242.

Hickok, G. (2010). The role of mirror neurons in speech perception and action word semantics. *Language & Cognitive Processes*, *25*(6), 749-776.
Kertesz, A. (2007). *Western Aphasia Battery – Revised.* San Antonio TX: Harcourt Assessment Company.
Laganaro, M., Pietro, M. D., & Schnider, A. (2006). Computerised treatment of anomia in acute aphasia: Treatment intensity and training size. *Neuropsychological Rehabilitation, 16*(6), 630-640.
NIDCD. (2008, October). Aphasia. Retrieved January 15, 2016, from http://www.nidcd.nih.gov/health/voice/pages/aphasia.aspx
Palmer, R., Enderby, P., Cooper, C., Latimer, N., Julious, S., Paterson, G., . . . Hughes, H. (2012). Computer Therapy Compared With Usual Care for People With Long-Standing Aphasia Poststroke: A Pilot Randomized Controlled Trial. *Stroke, 43*(7), 1904-1911.
Petheram, B. (1992). A survey of therapists' attitudes to computers in the home-based treatment of adult aphasics. *Aphasiology, 6*(2), 207-212.
Petheram, B. (2004). *Computers and aphasia: Their role in the treatment of aphasia and the lives of people with aphasia* Psychology Press.
Pluta, A. (2009). The Effectiveness of Rehabilitation Based on an Original Computer Program: Case Study of a Patient With Kinaesthetic Aphasia. Psychology of Language and Communication, 13(1).
Raymer, A., & Kohen, F. (2006). Word-retrieval treatment in aphasia: Effects of sentence context. *The Journal of Rehabilitation Research and Development JRRD, 43*(3), 367.
Rosenblum, L. D., Miller, R. M., & Sanchez, K. (2007). Lip-Read Me Now, Hear Me Better Later: Cross-Modal Transfer of Talker-Familiarity Effects. *Psychological Science (Wiley-Blackwell)*, *18*(5), 392-396. doi:10.1111/j.1467-9280.2007.01911.x
Shindo, M., Kimitaka, K., & Tanaka, Y. (1991). Speech discrimination and lip reading in patients with word deafness or auditory agnosia. *Brain and Language, 40*, 153-161.
Smith, Z. M. (2015). *Treating auditory attention to improve auditory comprehension in persons with aphasia* (Order No. 1594780). Available from ProQuest Dissertations & Theses A&I. (1709274348).
Stimley, M., & Noll, J. (n.d.). The effects of communication partner familiarity on the verbal abilities of aphasic adults. *Aphasiology,* 173-180.
Tips for Getting More Therapy. (2015, March 6). Retrieved January 15, 2016, from http://strokeassociation.org/STROKEORG/LifeAfterStroke/RegainingIndependence/TipsforDailyLiving/Tips-for-Getting-More-Therapy_UCM_310106_Article.jsp#.Vpk8xNAwjzI
Wilson, R. H., Zizz, C. A., Shanks, J. E., Cuasey, G. D. (1990). Normative data in quiet, broadband noise, and competing message for the Northwestern University Auditory Test No. 6 by a female speaker. *Journal of Speech and Hearing Disorders, 55,* 771-778
Youse, K. M., Cienkowski, K. M., & Coelho, C. A. (2004). Auditory-visual speech perception in an adult with aphasia. *Brain Injury, 18*(8), 825-834.

Appendices

ADULT WITH APHASIA CONSENT FOR PARTICIPATION IN STUDY

Study title: Effects of familiarity and presentation mode on auditory-visual speech recognition in adults with aphasia.

Investigator: Dr. Mary Gospel

I, ______________________________, consent to participation in this research project.

1. Procedures

This study looks at speech recognition and listening effort in adults with aphasia. The study will take about two hours in Jordan Hall 074. You will be asked some questions about your background. Your vision, hearing, and memory will be tested. Your speed on a computer will be measured. You will be given several tests of speech and language. Some tests will be done from and video and some tests will be done with a live person talking. We will keep track of your answers and measure how quickly you answered.

2. Risks and Benefits

The only unlikely risks from this study are feeling uncomfortable answering questions during the survey and a potential loss of confidentiality. Please let me know if you would like to skip a question you feel uncomfortable about. To guard your confidentiality, we will keep all recordings and data in a locked filing cabinet in the locked lab, or in a password protected folder in the locked lab. We do not anticipate that you will benefit from this research. Your participation may contribute to better understanding of speech recognition in adults with aphasia.

Your participation in this project is voluntary. You can take a break at any time. You can decide not to participate in this study at any time. You will still be paid for your time if you don't finish. You may withdraw at any time by telling me you wish to stop without any penalty. Your data will not be utilized if you do not finish the study.

The information obtained from this study may be published or presented at scientific meetings, but your identity will be kept confidential.

I have had the opportunity to ask questions about the project and my questions were answered. I understand that participation is voluntary and that I can withdraw at any time. My records will be kept confidential. The government, when required by law may review this study. A copy of this paper has been give to me. I understand that if I have any questions concerning the study, I can contact the Investigator.

Signature of Participant Date

Signature of Investigator Date

Signature of Witness Date

If you have any questions please contact:
Dr. Mary Gospel: (317) 940 - 8701

CAREGIVER CONSENT FOR PARTICIPATION IN STUDY

Study title: Effects of familiarity and presentation mode on auditory-visual speech recognition in adults with aphasia.

Investigator: Dr. Mary Gospel

I, ______________________________, consent to participation in this research project.

1. Procedures

This study looks at speech recognition and listening effort in adults with aphasia. The first portion of the study will take less than an hour in Jordan Hall 074. You will be asked to read out loud a series of sentences. You will be recorded on a video camera and this video will be shown to the adult with aphasia you are familiar with. The second portion will also take place in Jordan Hall 074. Your portion will take less than an hour. When you return with the adult with aphasia you are associated with, you will read out loud a series of sentences while the adult with aphasia listens to you.

2. Risks and Benefits

The only extremely unlikely risk from this study is a potential loss of confidentiality. To guard against this, we will keep all recordings and data in a locked filing cabinet in the locked lab, or in a password protected folder in the locked lab. We do not anticipate that you will benefit from this research. Your participation may contribute to better understanding of speech recognition in adults with aphasia.

Your participation in this project is voluntary. You can take a break at any time. You can decide not to participate in this study at any time. You will still be paid for your time if you don't finish. You may withdraw at any time by telling me you wish to stop without penalty. Your data will not be utilized if you withdraw from the study.

The information obtained from this study may be published or presented at scientific meetings, but your identity will be kept confidential.

I have had the opportunity to ask questions about the project and my questions were answered. I understand that participation is voluntary and that I can withdraw at any time. My records will be kept confidential. The government, when required by law may review this study. A copy of this paper has been give to me. I understand that if I have any questions concerning the study, I can contact the Investigator.

Signature of Participant Date

Signature of Investigator Date

Signature of Witness Date

If you have any questions please contact:
Dr. Mary Gospel: (317) 940 - 8701

Participant Information

Date: ____________________________

Experimenter: ____________________

Participant: ____________________________________

Initials to be used for data encoding: ____________________________

Gender: ____________________________

Age (D.O.B.): ______________________________

Education:

What is the highest level of education that you achieved?
(How far did you go in school?):

Language background:

Native English Speaker?: Y / N

Where were you born?: ______________________________

Vision

Need vision correction?: Y / N

Type: Contact lenses Glasses

Vision notes:

Results from LEA symbols test (acuity): ___________________

Hearing

Audiogram (see attached): __________________________

Patient reports difficulty with hearing:

With Individuals: _____________

In Groups: ________________

When music is playing:

Speech on TV:____________________

Determining direction of sound:

Confused __________ OK__________ Varies _________

Telephone preference : Right Ear_______ Left Ear : ________

Response Time

Baseline measures of response time to auditory stimuli ___________

Baseline measures of response time to visual stimuli ___________

Baseline measures of response time to auditory-visual stimuli. ___________

Working Memory

Working memory – auditory digit span ___________

Working memory – visual digit span ___________

Aphasia

Onset (date / duration):____

Etiology: ____

Western Aphasia Battery score: _____________________________________

Other notes:

Cognitive Tests

Subject initials: ___________

Visual Response Time

Trial 1: _________ seconds

Trial 2: _________ sec

Trial 3: _________ sec

Trial 4: _________ sec

Trial 5: _________ sec

Average time: _________ sec

Multimodal Response Time

Trial 1: _________ seconds

Trial 2: _________ sec

Trial 3: _________ sec

Trial 4: _________ sec

Trial 5: _________ sec

Average time: _________ sec

Auditory Response Time

Trial 1: _________ seconds

Trial 2: _________ sec

Trial 3: _________ sec

Trial 4: _________ sec

Trial 5: _________ sec

Average time: _________ sec

Visual-Aural Digit Span

visual digit span: _______

aural digit span: ________

Visual digit span

5 7

6 1

2 8 5

3 5 2

8 2 1 9

7 0 9 6

7 0 1 9 8

5 6 4 7 2

1 9 2 9 6 1

5 3 0 2 6 3

3 8 4 8 0 3 9

5 2 3 8 7 2 6

1 9 1 4 6 5 2 1

2 6 8 0 9 7 4 1

3 4 8 2 1 6 5 0 1

1 4 9 3 2 8 6 8 9

7 8 2 8 7 4 2 9 8 7

9 3 5 1 4 6 7 9 8 5

Aural Digit Span

4 1

2 7

3 6 2

9 2 0

8 5 9 5

1 9 5 6

8 7 1 3 5

8 0 1 9 1

4 1 2 4 7 0

1 6 5 7 2 5

2 1 8 4 1 9 3

8 3 7 5 8 7 8

2 3 4 6 6 8 4 6

8 8 3 2 4 9 2 7

7 1 6 4 7 0 4 8 5

1 8 0 4 0 7 3 6 1

8 1 6 7 3 1 7 6 4 7

2 4 1 3 7 8 2 7 5 9

Stimuli for Tasks of Speech Recognition

	Live Voice	Recorded Voice
Familiar Speaker	• Caregiver reads NU-6 words – List 2 • Caregiver reads CID sentences – List A	• Recording of caregiver reading NU-6 words – List 1 • Recording of caregiver reading CID sentences – List C
Unfamiliar Speaker	• Research assistant reads NU-6 words – List 2.1 • Research assistant reads CID sentences – List E	• NU-6 words from Butler Auditory-Visual corpus – List 2.2 • CID sentences from Butler Auditory-Visual corpus –List F

Familiar Live:
Northwestern University Auditory Test No. 6, List 2

- bite
- book
- bought
- calm
- chair
- chief
- dab
- dead
- deep
- fail
- far
- gaze
- gin
- goal
- hate
- haze
- hush
- juice
- keep
- keg
- learn
- live
- loaf
- lore
- match
- merge
- mill
- nice
- numb
- pad
- pick
- pike
- rain
- read
- room
- rot
- said
- shack
- shawl
- soap
- south
- thought
- ton
- tool

- turn
- voice
- wag
- white
- witch
- young

- CID Sentences, List A
    1. Walking's my favorite exercise.
    2. Here's a nice quiet place to rest.
    3. Our janitor sweeps the floors every night.
    4. It would be much easier if everyone would help.
    5. Good morning.
    6. Open your window before you go to bed!
    7. Do you think that she should stay out so late?
    8. How do you feel about changing the time when we begin work?
    9. Here we go.
    10. Move out of the way!

Familiar Recorded:

- Northwestern University Auditory Test No. 6, List I

met
mode
moon
nag
page
pool
puff
rag
raid
raise
reach
sell
shout
size
sub
sure
take third
tip
tough
vine
week
which
whip
yes
love

bean
boat
burn
chalk
choice
death
dime
door
fall
fat
gap
goose
hash
home
hurl
jail
jar
keen
king
kite
knock
laud
limb
lot

Test:

1. Where have you been all this time?
2. Have you been working hard lately?
3. There's not enough room in the kitchen for a new table.
4. Where is he?
5. Look out!

- CID Sentences, List C
    1. Everybody should brush his teeth after meals.
    2. Everything's all right.
    3. Don't use up all the paper when you write your letter.
    4. That's right.
    5. People ought to see a doctor once a year.
    6. Those windows are so dirty I can't see anything outside.
    7. Pass the bread and butter please!
    8. Don't forget to pay your bill before the first of the month.
    9. Don't let the dog out of the house!
    10. There's a good ballgame this afternoon.

Unfamiliar Live:

- Northwestern University Auditory Test No. 6, List 3

bar	mouse
base	name
beg	note
cab	pain
cause	pearl
chat	phone
cheek	pole
cool	rat
date	ring
ditch	road
dodge	rush
five	search
germ	seize
good	shall
gun	sheep
half	soup
hire	talk
hit	team
jug	tell
late	thin
lid	void
life	walk
luck	when
mess	wire
mop	youth

CID Sentences, List E

1. You can catch the bus across the street.
2. Call her on the phone and tell her the news.
3. I'll catch up with you later.
4. I'll think it over.
5. I don't want to go to the movies tonight.
6. If your tooth hurts that much you ought to see a dentist.
7. Put that cookie back in the box!
8. Stop fooling around!
9. Time's up.
10. How do you spell your name?

Unfamiliar Recorded:

- Northwestern University Auditory Test No. 6, List 4

back	mob
bath	mood
bone	near
came	neat
chain	pass
check	peg
dip	perch
dog	red
doll	ripe
fit	rose
food	rough
gas	sail
get	shirt
hall	should
have	sour
hole	such
join	tape
judge	thumb
kick	time
kill	tire
lean	vote
lease	wash
long	wheat
lose	wife
make	yearn

- CID Sentences, List F
    1. Music always cheers me up.
    2. My brother's in town for a short while on business.
    3. We live a few miles from the main road.
    4. This suit needs to go to the cleaners.
    5. They ate enough green apples to make them sick for a week.
    6. Where have you been all this time?
    7. Have you been working hard lately?
    8. There's not enough room in the kitchen for a new table.
    9. Where is he?
    10. Look out!