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The Impact of Accessible Email on the Written Communication of People with Aphasia

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THE IMPACT OF ACCESSIBLE EMAIL ON THE WRITTEN COMMUNICATION OF PEOPLE WITH APHASIA

by

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ABSTRACT

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Aphasia is a language disorder affecting individuals' ability to speak, listen, read, and write. Because of repeated communication breakdowns, people with aphasia often avoid social interactions, which can lead to feelings of social isolation. Email may reduce the frustrations of face-to-face communication by providing additional time to compose and revise messages. The purpose of this study was to investigate how the use of email would impact functional communication and social participation in people with aphasia. A single-subject, multiple-baseline across participants design was used to evaluate the effect of a simplified email program on participants' written communication skills and feelings of social isolation. Two individuals with moderate aphasia participated in the study; a 52-year-old female, two years post-onset and a 72-year-old female, three years post-onset. Participants were instructed how to use a simplified email program until the program was mastered. Composition time and error rates were analyzed to determine if there was any change in written communication skills. Both participants saw a decrease in composition rates, while error rates for both participants were unchanged. Effective conveyance of

intended messages were judged by unfamiliar readers using a 5-point rating scale. One participant reported an increase in her comprehension abilities, while comprehension ratings of the other participant decreased over the course of the study. Feelings of social isolation and satisfaction with the instructional program were evaluated using surveys. While both participants were satisfied with the CogLink program, neither participant experienced a measurable change in feelings of social isolation.

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Introduction

Aphasia and Language Deficits

Aphasia is an acquired communication disorder due to brain damage. Approximately 85 percent of all aphasias are caused by cardiovascular accidents to the left hemisphere. Of all people who survive a stroke, it is estimated that between 35 to 55 percent have some form of aphasia. (Dickey et al., 2010; Pedersen, Jorgensen, Nakayama, Raaschou & Olsen, 1995; Scarpa, Colombo, Sorgato, & DeRenzi, 1987). Other causes of aphasia include traumatic brain injury, tumors, degenerative diseases, and medical procedures. According to the National Institute for Deafness and Other Communication Disorders, over 100,000 people in the United States are diagnosed with aphasia each year, and there are approximately one million people living with aphasia (2012).

The communication difficulties experienced by people with aphasia (PWA) encompass all facets of communication. Aphasia disrupts multiple subsystems of language, impacting expressive language in both speaking and writing and receptive language in both auditory comprehension and reading comprehension. One common characteristic of aphasia is its impact on oral expression. PWA may have difficulty with word-finding, sentence formulation, or the use of grammar. Oral expression of PWA can also be marked by overuse of automatic speech and over-learned expressions. PWA may also have trouble with the coordination, planning, and production of speech and exhibit phonological and articulation errors due to concomitant motor-speech deficits of apraxia and dysarthria. Aphasia is different for each person affected, as the specific severity

and expression of these characteristics is highly individualized. However, the language disruptions experienced by all PWA impact their ability to communicate with others effectively and efficiently.

Reading and Writing Treatment for PWA

Deficits of reading include difficulty with decoding letters (letter-to-sound conversion), attaching meaning to words, comprehending sentences, to understanding written language at the paragraph level. Visuo-perceptual deficits and visual neglect may also prevent PWA from being able to scan a full page and from seeing words on one side of the page, interfering with comprehension. (Ellis, Flude, & Young, 1987)

Deficits in writing include writing individual letters of the alphabet, spelling words, combining words into sentences or combining sentences into coherent sequences of sentences (Basso, Taborelli, & Vignolo, 1978). Typically, writing ability does not surpass oral expressive abilities (Goodglass, Kaplan, & Barresi, 2001). PWA may have trouble reproducing individual letters of the alphabet on demand, but retain the ability for some automatic writing, such as their own names. Problems with writing may be further exacerbated by physical difficulty with the act of writing. Damage to the left hemisphere of the brain can often lead to right-sided paresis. For people who were right-handed, the paresis would complicate that person's ability to use writing as an effective communication modality.

The additional time to plan, revise, and edit, that writing requires, may seem like it would facilitate communication, but this is not always the case. The

severity of language impairments due to aphasia negatively impact people's ability to compose written language, which can outweigh the benefits of extended time. General word finding difficulties can persist and affect writing despite the reduced time constraints and ability to revise the message (Behrns, Ahlsn, & Wengelin, 2008).

Mortensen (2005) compared the writings of ten participants with aphasia to ten participants with TBI and ten control participants. Each participant was asked to write a picture narrative and to complete a simulated informal letter to a close friend or family member. There were no time restrictions for either task and participants were cued to reread and edit their work. PWA wrote shorter texts with a fewer number of topics within each sample than the individuals with TBI or the control participants. Participants with aphasia and those with TBI were able to construct the appropriate global discourse structure by using obligatory elements such as an opening, body and a closing. What differentiated the two groups from each other was the complexity and length of writing samples and the number of topics included.

Most studies which investigated reading and writing treatments for PWA were at the phoneme/grapheme or word level. One such study by Beeson & Egnor (2006) suggested that targeting oral and written output during naming tasks, increases oral word-finding skills for targeted words over naming tasks which are strictly oral. This study included two participants with moderate aphasia. The Copy and Recall Treatment (CART; Beeson, 1999; Beeson, Hirsch, & Rewega, 2002; Beeson, Rinsing, & Volk, 2003; Clausen & Beeson,

2003), in which participants copy a single written target word multiple times in sets of up to ten words, was used in conjunction with oral repetition of the target word. Each subject practiced five words which were targeted through writing only and five words which were targeted through writing and oral repetition. The participants were able to recall target words both in writing and orally better than when words were targeted through writing only. This study focused on writing at the word level and did not address longer utterances. This study also did not address generalization to spontaneous recall of target words for social communication.

A single-subject case study by Panton and Marshall (2008) targeted spelling, writing to dictation, and note-taking in a 56 year old participant with chronic aphasia, dysgraphia, and right hemiparesis. The treatment targeted the spelling of an individualized list of 30 words, using a method based on the CART approach (Beeson et al, 2002), and note-taking skills from a phone message and a dictated news article. The notes taken by the participant were short phrases consisting of key information. This study found that improvements in spelling were item-specific and did not generalize well into the note-taking tasks.

In one of the few studies which addressed writing at the paragraph level, Behrens and colleagues (2008) analyzed the writing samples of PWA, who were asked to write about a frightening experience. The participants were eight individuals with aphasia (two women and six men) aged 28 to 63, with a mean age of 42.5 years. The control group was comprised of university students (five women and five men) with no history of language deficits aged 21 to 30, with a

mean age of 23.5 years. It was found that the individuals with aphasia typically wrote fewer words per minute, had more word-level errors, and had more difficulty revising the texts than the control group. However, these results must be viewed cautiously due to the fact that the control participants were not matched to the participants by age, gender, or educational level.

Spoken Versus Written Language

There are inherent differences between the spoken and written modalities. The characteristics of each modality can simultaneously facilitate and create barriers to communication. During spoken communication, the speaker and listener usually face each other. Face-to-face communication provides the listener with more contextual cues in the form of non-verbal facial expressions, gestures, and visual cues. Additionally, the listener is able to provide immediate and specific feedback. Attempts to correct communication breakdowns can be made in the moment, before further miscommunication occurs.

In spite of these advantages, a significant drawback to face-to-face communication is the pressure of the time constraints in spoken communication. There are social norms associated with response time and turn taking and PWA may feel pressure to meet those standards. Listeners may also be using non-verbal body language or facial expressions to indicate that they are having difficulty understanding. While PWA may recognize these signals, they may not have the ability to repair the communication breakdown, adding to the communication pressure and frustration.

Most often writing takes place with the writer and listener separated by space and/or time. A positive aspect afforded through the use of the written modality is the opportunity to take additional time for edits and revisions in the message to be communicated, thereby reducing the pressure to meet social time constraints. PWA have the ability to take the additional time they need to try to construct the intended message.

A major drawback to written language is that there is no feedback from readers and communication repairs must occur after messages have been delivered. The lack of contextual cues also requires the writer to use more specific and detailed information through more vivid vocabulary and more complex syntactic forms.

There is research which suggests that information is more effectively conveyed by PWA to unfamiliar communication partners when using the written narrative rather than an oral narrative (Behrns, Wengelin, Broberg, & Hartelius, 2009). The researchers analyzed the performance of eight participants on written and spoken narratives by comparing the total number of words, lexical diversity and lexical density, and words per T-unit (a main clause plus any associated subordinate clauses) and clauses per T-unit. Spoken and written samples were also rated on a bipolar scale (21 antonym pairs) by 60 untrained readers/listeners. The participants were all more than six months post onset with mild to mild-moderate aphasia. Participants wrote a narrative and then orally told the same story. There was no significant difference in the total number of words, lexical diversity, and lexical density between the PWA group and the control

group. The control group had significantly higher number of words per T-unit and clauses per T-unit than the PWA group. Naive raters reported that it was easier to understand the control group's oral and written narratives, but also that the written narrative from the PWA group was more easily understood than the spoken narrative. However, results need to be considered with caution because the tasks which were compared were not equivalent. The first task was a written narrative and the second task was ultimately a story retell task. The memory, processing, and linguistic skills required for the generation of an original narrative versus a story retell task are not the same (McNeil, et al., 2007). A narrative would require the participant to organize thoughts and ideas into story grammar elements, retrieval of desired vocabulary, compose grammatically correct sentences, and organize all of these elements into the appropriate discourse structure. A story retell task would require the participant to recall the narrative, recall and organize facts and events in the appropriate sequence, retrieve desired vocabulary used in the target story, respond using grammatically correct sentences, and organize all of these elements into an oral narrative. By writing the narrative out first, this may have improved the performance of the oral retelling. It is difficult to draw the conclusion that the written language of PWA is more easily understood than spoken language by comparing a written narrative and the oral retelling of the same narrative.

Overall, most research investigating the written skills of PWA addresses writing at the word level. Word level studies often investigate writing as a possible compensatory strategy or as a means to support or improve spoken

language. Studies which explore longer texts indicate that PWA tend to write shorter sentences and phrases, focusing on key content words. Also, PWA tend to have more difficulty revising written texts (Behrens, Ahlsen, & Wengelin, 2008).

Effects of Language Deficits on Social Interaction

The investigation of writing supports that facilitate participation is especially important because PWA are at great risk for social isolation. The language disruptions experienced by PWA can impact social interactions as they create barriers to effective communication. The communication breakdowns can cause frustration for both communication partners and as a consequence communication and interaction is often avoided, reduced, or restricted. The loss of friends and social networks is associated with aphasia, as is aversion to social interactions due to the anxiety and stress related to the communication difficulties (Northcott & Hilari, 2011). According to Sohlberg, Ehlhardt, Fickas, & Sutcliffe (2003), social isolation is often reported to be one of the most troubling problems for individuals with cognitive-linguistic impairments, such as aphasia. Social isolation has been shown to be associated with depression following a stroke (Appelros & Viitanen, 2004). Therefore, it is important to investigate ways to facilitate functional use of language to improve social participation.

Communication and Participation

The International Classification of Functioning, Disability and Health (ICF; WHO, 2001) provides standard language and a framework for professionals across disciplines and across nationalities to understand and discuss functioning

and disability (Ma, Threats & Worrall, 2008). It describes the interaction between a Health Condition (disease or disorder), Body Functions and Structures (anatomy and physiology), Activities (e.g. speaking), Participation (e.g. maintaining a conversation), and extenuating factors (Environmental Factors and Personal Factors) as seen in Figure 1 (ICF; WHO, 2001). Based on the ICF, most of the previous work investigating PWA and reading and writing skills is conducted at the Body Functions and Structures (impairment) level. Many of the studies described here attempt to make impairment level changes by using functional activities. However, these functional activities are limited to the clinical setting. It is important to consider interventions that address Activities and Participation. There is a paucity in research that addresses the needs of PWA at the Participation level, where the goal of intervention is not solely to remediate deficits (impairments), but to incorporate supports to facilitate participation in meaningful life activities.

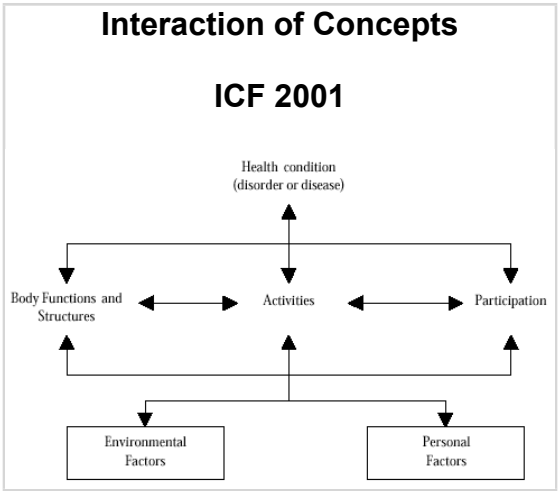

Figure 1: Interactions of International Classification of Functioning, Disability and Health Concepts (ICF; WHO, 2001)

Computerized Writing Supports

Recent research that addressed the effects of computerized writing supports for PWA has shown promising results for improving written communication. In a study by Behrns, Hartelius, & Wengelin (2009) three participants with mild to mild-moderate chronic aphasia were taught to use one computerized writing aid while writing about pictures found in books of personal interest. Each participant was able to choose the writing aid they felt would be most useful. Two participants used a word prediction program and one participant used a spell checker while writing. The results demonstrated that the post-treatment texts produced were longer with fewer word-level errors and more successful edits. A limitation of this study was that the tasks were only measured in a clinical setting and although the task was functional, it did not evaluate effects on participation.

Email, the Internet, and Social Media

Email. More recently, researchers have begun to look at writing and electronic communication to improve social interactions and communications for individuals with aphasia. In a survey conducted by Elman & Larsen (2010) of 33 individuals with aphasia, 79% (26/33) had used a computer prior to onset. The most common pre-morbid uses for computers included word processing, email, and online searches. It was also reported that 58% or participants continued to use computers after their stroke. The most common uses following the onset of aphasia included email and access to online news. Of the 33 participants 27 (82%) reported that they were interested in using the computer. The two most

frequently identified motivations for future computer use included online news or sports and email. Elman & Larsen (2010) note that the survey took place before the rise of other forms of electronic communication such as Facebook, Twitter, and Skype; but that email and other forms of social media may be useful in addressing feelings of social isolation in PWA.

Independent use of email to facilitate communication and social interaction in individuals with acquired neurogenic disorders was investigated through a five year study: *Think and Link: Email for Individuals with Cognitive Disabilities* (2001, National Institute on Disability and Rehabilitation Research Grant #H133A010610). As a part of the larger project, a pilot study was conducted by Sohlberg, Ehlhardt, Ficas, and Sutcliffe (2003). The purpose of this pilot study was to design and then determine the usability of a simplified email system for individuals with cognitive-linguistic impairments (CLI) due to acquired brain damage. Specific aims of the project were 1) to determine what type of writing cues were needed, 2) to identify problems that occurred while using a simplified email package, and 3) to explore the possible effects of successful email usage on feelings of social isolation. The researchers reviewed available literature to obtain initial information on obstacles to and difficulties with using standard email programs.

They also interviewed three individuals with CLI. After demonstrating a prototype of the simplified email system to be used in the study, the individuals were given the opportunity to use the prototype and then to give feedback on its design and function. Based on the results of this discussion it was determined

that email users with CLI had difficulties due to the interface design: 1) finding command buttons, 2) maneuvering the mouse, 3) using word processing commands, and 4) locating information on the screen. The use of email was compromised by writing difficulties stemming from CLI including: 1) choice of topic, 2) selection of information to include, and 3) writing conventions and mechanics. The simplified email system was further refined based on the findings. An interface was used which hid most of the operating system, and limited the function to only the email system.

To test the email interface there were eight participants ages 26 to 78 with acquired brain injury, who were all more than two years post-onset. At least one participant fell into each of the following etiologies of acquired brain injury: right hemisphere cerebrovascular accident (CVA), left hemisphere CVA, TBI, anoxic brain damage, and early dementia. Only one of the eight participants was diagnosed with aphasia. In this study, the participants were required to have little to no computer experience prior to their injury. During one individual session, each participant wrote four emails based on four different types of prompt conditions: no prompt, idea prompt (a topic with an outline of information to be included), fill-in-the-blank (email template with blanks for participant to fill in with their own text), and multiple choice (email template with drop down boxes for the participants to choose from). No prompt format was found to be preferred by the participants as a group. The different preferences for prompt format could have been related to the wide variety of deficits seen in the participants. This study found that the participants as a group had trouble learning how to manipulate the

mouse, how to use the keyboard for word processing functions (e.g. moving the cursor, deleting with backspace), correcting errors, and using the interface buttons. This could have been due to the lack of computer operation skills of the participants, but also complicated by the acquired brain disorders. Four main problems due to the nature of acquired brain disorders were found to impact email composition: a) remembering the email topic, b) coming up with ideas and information to include, c) lack of a letter writing script (e.g. greetings and closings were generally absent), and d) difficulty identifying and correcting errors. All participants were interested in continuing to use email to communicate with other friends and family members. The researchers concluded that making email accessible to individuals with CLI could increase social interactions, therefore decreasing feelings of social isolation.

After the initial pilot study, a survey of opinions and perspectives on email usage by individuals with acquired cognitive impairments (ACI) was completed by 133 individuals with ACI, professionals, and caretakers. (Todis, Sohlberg, Hood, & Fickas, 2005) It was revealed that among respondents with ACI, 82% indicated that they used computers after the onset of their cognitive impairment. Of all respondents, 49% reported they used email to communicate with friends and family. This was the most common means of communicating with friends and family who lived more than one hour away from the respondent. Results also demonstrated that there was no significant age difference between computer-users and non-computer users among the respondents with ACI (computer users = 32.4 years old, non-users = 40.44 years old). Of individuals

who did not use the computer, the primary reason was that computer usage was too complicated (57%).

Focus groups were conducted with 66 individuals with ACI and 20 caregivers, to discuss experiences with the use of technology, computers, and email. (Todis, Sohlberg, Hood, & Fickas, 2005) Participants were asked to discuss barriers to the use of technology, problems encountered during email usage and what types of supports they would find useful in overcoming the barriers and problems. During the course of these discussions, the advantages and disadvantages of email usage were addressed. Advantages included that the participants could: 1) keep in contact with people they would not telephone due to the cost associated with long distance calls, 2) produce email when it is convenient, formulate and compose messages with reduced time pressure, and 3) experience reduced accuracy pressures due to the ability to revise and edit. Disadvantages included that the participants: 1) face the higher cost associated with maintaining an email account and internet access, 2) could have difficulty sorting through the large number of junk emails to identify desired emails, and 3) would not be able to enhance communication through the use of the non-verbal cues of in-person interactions. Many individuals who did not have computer experience prior to onset, were concerned that it would be too difficult to learn the new skills needed to operate a computer and maneuver through an email package. Based on the results of the focus groups, a list of needs, accommodations, and desired supports preferred in a simplified email package was developed. This list included: 1) simple set up, 2) reduced images on the

screen, 3) step-by-step instructions and cues, 4) simplified spell check, 5) text-to-speech and speech-to-text, 6) limited address book, 7) a spam filter, and 8) personal customization. Researchers then used this information to revise their beta version of the simplified email system to develop a more robust system to be studied further.

The revised simplified email system was then tested by people with traumatic brain injury (TBI; Sohlberg, Fickas, Ehlhardt, & Todis, 2005). This longitudinal study followed four participants ages 37 to 65 with TBI at least two years post-onset. A PC with the simplified email system developed from the results of the previous two studies was set up in the home of each participant. Over the course of two to three months, each participant was given individual training on the use of the PC and the email system. The number of sessions ranged from 21 to 43, based on the needs of each participant to be able to operate the system independently. Data on email use was gathered weekly over 4 to 6 months. Information was collected on rate of composition, length of compositions, the number of emails sent versus the number of emails received, and the number of sent emails versus the number of abandoned emails. The emails sent were monitored for changes in quality of compositions and exchanges with communication partners. Post-treatment evaluation also included interviews with the participants and their communication partners to assess changes in social interactions. This research was able to show that the chosen writing supports helped to facilitate the increased use of email for social

communication and that the increased use of email reduced feelings of social isolation in individuals with TBI.

Following the conclusion of the study, the email interface developed during the project was marketed and made commercially available under the name CogLink. The email interface was bundled with a simplified internet interface, a self-guided computer training program, and games under the name Public Access Computer Key (PACK; 2010). The PACK was developed through SBIR grant number H133S070096 from the National Institute of Disability and Rehabilitation Research. The PACK is a USB compatible device, which provides the user a simplified screen with four buttons for each of the above items. This device can be used with any personal computer (PC or Mac) either at the user's home or a public access computer (Fox et al., 2009, Fox et al., 2010).

Online Communities. Two separate internet and email based communities for individuals with aphasia have been developed. See Table 1 for a comparison of the online communities for PWA. The first, Simulation of Oral Communication Research Analysis and Transcription Engineering System (SOCRATES), was developed at the Aachen University in the Federal Republic of Germany (Spaniol, Springer, Klamma, & Jarke, 2004). This community gives individuals with aphasia the opportunity to live chat with other individuals with aphasia, therapists, and researchers. No published research is available which investigates whether this online community helps individuals with aphasia to communicate more effectively or efficiently or whether it helps to reduce feelings of social isolation. The second online community was developed in the

Netherlands in conjunction with the Aphasia Union Netherlands (Al Mahmud & Martens, 2011). This system is restricted to individuals with aphasia, who reside in the Netherlands and are members of the Aphasia Union Netherlands, family members, and therapists. Through this system, PWA and other members are able to contact one another via an email interface specifically designed to meet the needs of individuals with aphasia. The interface was designed to minimize distractions, simplify the buttons, while also providing writing aids. The writing aid reported to be most widely used by individuals with aphasia was a set of phrases pulled from incoming emails to which a member is responding. The system also includes a mini-dictionary, which is developed for each individual with the assistance of a speech therapist. Unfortunately, the language used throughout the system for directions, titles, labels, cues, etc. is Dutch, and the system is not available in English. Another drawback of this online community, is that PWA must be able to navigate to the home page using a traditional web browser on a standard operating system, or have assistance available.

In response to some of the criticism of the Aphasia Union Netherlands, a prototype of an email tool was developed by Al Mahmud & Martens (2013). The new tool, Amail, is an email client designed specifically to be accessible for PWA using input from speech therapists and PWA. PWA found the prototype to be more flexible with more features than the email interface through Aphasia Union Netherlands, but less confusing and complicated than Outlook or Hotmail. After several revisions, eight participants were recruited to test out the new email tool. The tool was individualized for each participant and each participant underwent

training on the use of the email tool. The participants were then asked to compose emails from a variety of prompts. A survey was administered to determine the preferences of writing supports, the overall feel of the tool, the ease of use, positives and negatives of the prototype. Participants were also asked what else they would like to see in such an email tool. Participants preferred a word selection tool, where they could select words from another email and a mini dictionary which could be customized with words and phrases specific to each participant. Overall, the participants were able to write and send emails independently. Participants recommended a text-to-speech feature and step-by-step instructions for reference. This prototype is a more powerful and more flexible email interface than the Aphasia Union tool; however, it is still in the experimental phase, is currently only available in Dutch, and the data collected on the effects on message content and accuracy are described only in qualitative terms. The next step for the researchers is a longitudinal study with additional participants with aphasia using quantitative data. While this program is exciting , it is not available to English speaking clients in the United States. The PACK is commercially available, but has only been evaluated by individuals with TBI.

Table 1

Comparison of Electronic Communication Programs

	CogLink/PACK	SOCRATES	Amail
Population	People with traumatic brain injury	People with aphasia, therapists, and researchers	People with aphasia
Number of participants	4	n/a	8
Language	English	German	Dutch
Format	email program	live chat	email program
Available writing supports	spell check, word prediction, text-to-speech	none	word prediction, personal dictionary, word selection tool

There is a range of approaches to electronic communication for PWA available through CogLink, SOCRATES, and Amail. SOCRATES relies on users supporting each other to facilitate communication. Its purpose is to give users a forum where they do not need to worry about how others will perceive individual communication deficits, because they all have a shared experience with aphasia. No other communication or writing supports are offered. CogLink and Amail both attempt to provide PWA a tool to facilitate electronic communication with friends and family members beyond the aphasia community. Both email systems provide a modified interface and writing supports. CogLink provides users with spell check, word prediction, and a text-to-speech tool. Amail provides users with an individualized mini dictionary and the ability to select words from incoming email messages. The effects of the use of CogLink on both the quality of outgoing messages as well as impacts of the system on feelings of social isolation was investigated with individuals with TBI. In the case of individuals

with TBI, CogLink was shown to have positive effects on both the quality of the outgoing message and feelings of social isolation. While the Sohlberg et al. (2005) study specifically addresses individuals with TBI, both individuals with TBI and PWA experience a loss of social interactions, due in part to language deficits. Research has shown that email is an effective tool to reduce feelings of social isolation in individuals with TBIs (Sohlberg et al., 2005). Amail has been focused specifically on individuals with aphasia, but has not fully investigated the impact of the system on message quality or feelings of social isolation. The studies by al Mahmud & Martins (2010, 2013) seem to imply that the use of an accessible email interface could potentially improve message accuracy and reduce feelings of social isolation. Unfortunately the Amail system is only available in Dutch. This study will attempt to fill this gap in the literature by evaluating the effects of a modified email system on the communication of PWA and the impact of email usage on feelings of social isolation.

Study Aims

This study investigated the use of an adapted email package with writing supports for individuals with aphasia. It was hypothesized that the adapted email package would make electronic communication (i.e. email) more effective and efficient, and therefore a more viable means of communication. This study also explored the use of electronic communication as a way to reduce feelings of social isolation, which is commonly experienced by individuals with aphasia.

These specific research questions were addressed:

1. Does the use of an adapted email program with electronic writing supports for PWA decrease the error rate in personal email messages? What types of errors remain, if any?

2. Does the use of an adapted email program with electronic writing supports for PWA increase the comprehensibility of personal email messages as judged by unfamiliar readers?

3. Does the use of an adapted email program with electronic writing supports for PWA decrease the composition time of personal email messages?

4. Does the use of an adapted email program with electronic writing supports for PWA improve the ease of use of personal email?

5. Does the use of an adapted email program with electronic writing support for PWA increase the use of personal email messages? If so, does the increased use of personal email messages decrease feelings of social isolation?

Methods

Research Design

A single-subject multiple baseline across participants design was used. The study consisted of four phases: baseline, intervention, maintenance, and post-maintenance. The baseline was established by taking a computer-based writing sample and calculating the composition rate by dividing the composition time by the total number of characters in each message on a minimum of three separate occasions. Intervention began after the establishment of a stable baseline. Baseline was deemed stable if it did not demonstrate an upward or downward trend. During the intervention phase, writing samples (i.e. probes) were gathered at the beginning of each treatment session. Intervention focused

on teaching each participant the following skills needed to use the CogLink program and accompanying writing supports: 1) plug in the PACK drive, 2) open the PACK drive, 3) open email, 4) read email, 5) use the read-back feature, 6) use word prediction, 7) send email, and 8) exit the PACK system (see Appendix A for task instructions). Participants were given a CogLink Directions handout for reference (see Appendix B). Intervention continued until the participant was able to independently complete the required tasks with or without the use of the CogLink Directions handout. After demonstrating independent use of the CogLink program on two consecutive sessions, participants began the maintenance phase. Maintenance consisted of three weeks where the participants used the adapted email package on their own. During the post-maintenance phase, a writing sample was collected and analyzed and a final interview was conducted to get the participants' opinions on the use of the adapted email package for email communication.

Participants

Recruitment. Three participants were recruited from the University of Wisconsin - Milwaukee Speech and Language Clinic and Milwaukee area support groups for PWA. All were diagnosed with mild to moderate chronic aphasia based on the results of the Western Aphasia Battery - Revised (Kertesz, 2007; WAB-R). They also met the following selection criteria: a) were a minimum of six months post injury, b) had basic computer skills (as per self-report and observation), c) used email prior to injury, d) had a minimum of two

potential email communication partners with email addresses, e) used English as their primary language, f) passed a vision screening (with or without corrective eyewear), g) passed a hearing screening, h) had access to a personal computer, and i) were able to provide informed consent. Left-handedness or concomitant deficits such as right-sided weakness was noted, but not used as exclusionary criteria.

Participant descriptions. The following are the case histories collected for each participant. All of the names used are pseudonyms to protect the identities of the participants and all medical information was self-reported.

Participant 1: Charlotte was a 52-year-old female with moderate aphasia due to a stroke which occurred 3 years ago. She began therapy at the Adult Neurogenic Clinic at UWM in Fall 2013. Charlotte presented with right-sided hemiparesis and used a wheelchair for mobility. Prior to her CVA, she was right-hand dominant, but now uses her left hand for writing. Charlotte worked as a buyer for a major department store and used email extensively prior to her stroke. Following her stroke, Charlotte did not work and rarely used email. She used a touchscreen tablet computer for watching the news and other videos and to access the internet after her stroke. Charlotte wanted to use email to reconnect with friends.

Participant 2: Emily was a 72-year-old female with moderate aphasia due to a series of CVAs 3 years ago. She had speech therapy following her CVAs while in the hospital, but has not participated in speech therapy since. Emily did not report any hemiparesis. At the time of her injury, Emily was working as a high

school teacher and used email regularly. Following her injury, she used the computer for access to the Internet and some email use, but needed mild assistance in opening up her traditional email program, finding the reply, new message and send buttons. Emily was interested in becoming more independent with email to help her participate in social and community groups related to her hobbies, which included fine arts and gardening.

Participant 3: Anne was a 68-year-old female who suffered a CVA more than 10 years ago. Following consent and one baseline session, Anne withdrew from the study due to mobility issues and time constraints.

Materials

Aphasia severity was assessed using the WAB-R. Vision was screened using the Patti Pics™ Vision Testing System (Precision Vision, 2007), an Amsler grid, and the line bisection and clock drawing subtests of the Boston Diagnostic Aphasia Examination (Goodglass, Kaplan, & Barresi, B, 2001; BDAE). A hearing screening was conducted using a Grason-Stadler GSI 18 audiometer.

The PACK drive (Fox et al., 2010) with the adapted email package, Coglink (Sohlberg, et al., 2003; Sohlberg et al., 2005; Todis, et al., 2005), and tutorials on the use of Coglink was used for assessment, the establishment of baselines, and treatment. To assess basic computer skills the training package available on the PACK drive was used with a laptop computer and external mouse. Either a MacBook Pro or Windows PC laptop was used, depending on the personal computer to which the participant had access, so that the treatment phase reflected the home experience.

The PACK is inserted into a computer's USB port and opens a simplified desktop with the options for a simplified email package, internet browser, games, and tutorials. It gives the user the ability to use publicly accessible computers or their own personal computer. The email package included is CogLink, which is a simplified email interface with writing supports developed for individuals with traumatic brain injury (TBI). The writing supports included in the package include word prediction, message templates, spell check, and voice read-back. A standard internet email package (e.g. Gmail, Outlook) was used during the baseline phase.

The Stroke and Aphasia Quality of Life Index (SAQOL-39; Hilari, Byng, Lamping, & Smith, 2003) was used to document participants' feelings of social participation and isolation as well as participants' attitudes towards their own communication skills (see Appendix C). The SAQOL-39 is a frequently used, validated measure to assess the quality of life of individuals after a stroke based on the following domains: physical, psychosocial, communication, and energy. It is one of the few tools available specifically for individuals after a stroke which also considers psychosocial and communication issues.

Procedures

Evaluation and Establishment of Baseline

The baseline was established over the course of the first three to five sessions for each participant. The baseline was considered stable when a

minimum of three data points showed no upward or downward trends. The timeframe for establishing the baseline was staggered for each participant.

Each baseline session was conducted by the researcher at the University of Wisconsin-Milwaukee Speech and Language Clinic or in the participants' homes. Each session lasted 45 minutes and participants were monitored for visible signs of fatigue and frustration. If signs of fatigue or frustration were noted, the researcher offered the participant a break. The sessions began with the collection of computer based writing samples. Participants were asked to compose one email for the baseline using a traditional email package and with writing supports disabled (i.e. spell check, word prediction, or dictionary). The researcher provided writing prompts both orally and in writing (see Appendix D for a list of all writing prompts). The prompt was read a maximum of three times. The participants had access to the written prompt while writing (see Appendix E for an example). The prompts were designed to elicit a paragraph level response in the writing sample. The prompts differed each session and were given in a randomized order for all participants.

Data were collected on composition time. A stopwatch was started after the prompt had been read out loud by the researcher. The time was noted when the participant typed the first letter and was stopped when he/she took her fingers away from the keyboard and indicated either verbally or gesturally (e.g., by looking to the researcher), that the message was complete. During baseline probes, the CogLink program was not used and no cues were given regarding the accuracy of the participants' messages or use of the CogLink program;

however, neutral statements were used to encourage the participant (e.g. “You are doing great,” “Nice job,” “You are working hard.”) Data were taken from the writing samples on the type and number of writing errors including: spelling errors, morphological errors, semantic errors, and syntactic errors, as was done in Behrns, Ahlsen, & Wengelin (2008). Spelling errors were determined using the “Merriam-Webster Online Dictionary” (2014). Semantic errors were identified by determining if the word choice made sense, given the context. Morphologic errors were defined as the absence of obligatory morphemes. Syntactic errors were defined as errors in the “rules that dictate the acceptable sequence, combination, and function of words in a sentence” (Catts & Kamhi, 2005). The total number of words, total number of errors, and the total for each error type for each probe was computed. The total number of characters was also counted and the composition time per character was calculated.

Following the writing samples, the participants completed an assessment battery and interview to measure and describe the following areas: case history, computer and email usage, quality of life, language, vision, and hearing. The hearing screening was conducted at 500 Hz, 1000 Hz, and 2000 Hz at 30 dB. The battery was completed over three to five baseline sessions depending on the stamina of each participant. Interview and survey questions determined previous computer usage, potential communication partners, handedness, and concomitant deficits. A copy of the tools used are in Appendicies F-H. The Stroke and Aphasia Quality of Life Index (SAQOL-39; Hilari, Byng, Lamping, & Smith, 2003) provided data related to the participants‘ social participation and

feelings of social isolation. Administration of the Western Aphasia Battery-Revised (WAB-R; Kertesz, 2007) was used to verify aphasia severity levels as well as overall expressive and receptive language skills. The participants' scores on the WAB-R are presented in Table 2. Charlotte's Aphasia Quotient was 57.6 and Emily's Aphasia Quotient was 69.9, which both correspond to moderate aphasia.

Table 2

Western Aphasia Battery - Revised Results

Participant	*Severity*	*Charlotte*	*Emily*
Aphasia Quotient (100)	Moderate (51-75)	57.6	69.90
Spontaneous Speech Score (20)		13.0	13.00
Auditory Verbal Comprehension Total (10)		8.2	9.35
Repetition Score (10)		1.7	7.20
Naming and Word Finding Score (10)		5.9	5.40

A vision screening was administered as a part of the evaluation process. Central visual acuity was assessed using the Patti Pics™ Vision Testing System (Precision Vision, 2007). An Amsler grid was used to screen for macular degeneration. The line bisection and clock drawing subtests from the BDAE were used to screen for visual neglect. The clock drawing subtest was also administered to screen for cognitive abilities and to rule out visual neglect which could have negatively affected the participants' performance in this study. The clock drawing subtest was also used for cognitive screening, such as the ability to follow directions and synthesize information (Shulman, 2000). All vision screening tasks were performed while the participant was wearing any corrective

eyewear. Both participants passed the vision screening and the clock drawing subtest. If a participant failed the vision screening, he/she would have been excluded from the study.

A hearing screening was also conducted to insure that the participant was able to take advantage of the read-back feature included with the CogLink email interface. Both participants passed the hearing screening at all frequencies tested. If a participant failed the hearing screening, he/she would have been excluded from the study. Basic computer skills were assessed through the use of the introductory tutorial included with the PACK. The tutorials familiarized the participants with the use of the mouse and the keyboard to manipulate elements on the screen. There were opportunities built into the program for the participants to practice and demonstrate these skills. Basic computer skills were also observed during the composition of a mock email from a writing probe using a standard email package. Both participants demonstrated basic computer skills. Once a stable baseline was established and all assessments had been completed, treatment began.

Intervention

Probes. Each intervention session began by collecting a writing sample to probe the participants' independent writing. Each session was conducted by the researcher at the University of Wisconsin-Milwaukee Speech and Language Clinic or in the participants' homes with each session lasting 45 minutes. Participants were monitored for fatigue. During each session, the participants used a PACK drive containing the CogLink email package. The PACK drive

remained with the researcher until treatment was concluded and the maintenance phase began. Each treatment session began with the computer set up with CogLink open to a new message screen. The participants were then instructed to compose an email message independently to a familiar communication partner from a writing prompt (refer to Appendix D) using the CogLink email package. The writing prompts were developed by the researcher to elicit writing samples with similar levels of complexity. The writing prompts were designed to replicate functional and social communication. The researcher then sent the email message to her University email account. The same procedures were used as in the baseline probes, the only difference being the email interface.

Email system training. The goal of intervention was to teach the participants how to use the PACK drive, including routines and procedures for loading the PACK Drive, starting up the PACK Drive, navigating to the CogLink email package, reading new email, writing new email, replying to email, and using the word prediction and read-back text tools. When the researcher introduced the participant to the PACK drive and CogLink system during the first intervention session, the researcher modeled the sequence for using the system from start to finish two times (see Appendix A for scripted procedures). Following the demonstrations, the researcher closed the program and removed the PACK drive from the computer. The participant was then asked to attempt the tasks independently. Written instructions for each procedure were provided to the participants (see Appendix B). The CogLink Directions Handout was developed

keeping in mind the recommendations for written health information for PWA (Rose, Worrall, Hickson, and Hoffmann, 2011).

In subsequent sessions the participants were asked to independently practice navigating through the tasks required for independent use of the PACK drive and CogLink program. The required tasks were as follows: insert the PACK into the computer, open up the PACK Drive, navigate to CogLink, read incoming email, send an email, use the word prediction program, and use the read-back text feature (see Appendix I). Participants were allowed to use the CogLink Directions Handout. In the practice trials the participants were given sample words presented in writing and verbally. During practice trials participants were not be asked to generate original writing samples. If the participants were unable to complete tasks independently during the practice trials, cues and support were given as needed, in the following hierarchy: 1) gesture to the procedure sheet, 2) verbal cue ("look at the instruction sheet"), and 3) spoken cues walking the participant through the procedure. A pause of 10 seconds was given before moving up the cueing hierarchy in order to give the participant time to respond. Each session included a minimum of two practice trials through the PACK drive and CogLink tasks and the participants were monitored for fatigue. When the participant was able to independently (i.e. without cues from the researcher) perform the required tasks with or without the use of the CogLink Directions Handout for two consecutive trials across two sessions the participant was ready for the maintenance phase.

Maintenance

Following the treatment phase, participants were given the PACK drive for their continued use at home on their own computers. The researcher did not have access to the actual email messages attempted, sent, or received during this time.

Post-Maintenance

After the three-week maintenance phase, participants came to the UWM Speech and Language Clinic or were visited in their homes, to give a post-treatment email writing sample using the CogLink email package on the PACK drive. The participant was given two writing prompts in the same manner as in the Baseline and Treatment phases. The prompts were presented orally and in writing. The prompts were read out loud by the researcher a maximum of three times and the participants had access to the written prompt while composing their email messages. The post-treatment session also included a final interview (see Appendix J), re-administration of the SAQOL-39, and administration of a computer usage survey (see Appendix H).

Writing Sample Ratings

After post-treatment writing samples were collected, the pre-treatment and post-treatment writing samples from all participants were read by 10 unfamiliar readers. The unfamiliar readers were recruited from undergraduate general education courses. Unfamiliar readers were native English speakers and did not have experience working in the UWM Speech and Language Clinic. The

unfamiliar readers were given the writing samples in a randomized order at staggered intervals. Unfamiliar readers were given the prompt for each email and the response. They were then asked to rate how easy the email message was to understand. A 5-point scale was used, with one being very difficult and 5 being very easy (see Appendix K for rating instrument). Table 3 provides a summary of all of the study phases and the data to be collected during each phase.

Table 3

Outline of Procedures and Data Collection

	Baseline	Intervention	Maintenance	Post-Maintenance
	•writing sample •testing & surveys	•writing sample •email instruction	•independent usage for 3 weeks	•writing sample •surveys •exit interview
Sessions				
Charlotte	1-3	4-5		6
Emily	1-5	6-7		8

Data Analysis

Research Question 1: Does the use of electronic writing supports by PWA decrease the error rate in personal email messages? What types of errors remain, if any? Data on each of the participant's writing performance measures (spelling errors, semantic errors, morphological errors, semantic errors, syntax errors, proportion of total number of errors to total number of words) from each

probe were graphed and visually analyzed to determine effectiveness of the use of the training and use of the CogLink email interface. A significant effect was determined to exist if there is a negative change in slope and level of the graphed data between the baseline and the end of the instructional phase. Percentage of non-overlapping data (PND) was also calculated for each measure by determining the number of data points in baseline and post-maintenance which do not overlap and dividing this by the total number of data points to determine if the effect was significant. A high PND indicates a decrease in error rate , while a low PND indicates no significant change in the error rate from baseline.

Research Question 2: Does the use of electronic writing supports by PWA increase the comprehensibility of personal email messages as judged by unfamiliar readers? The unfamiliar partner ratings of comprehensibility were compared pre and post treatment for each participant. T-tests ($p<0.05$) were used to determine if there was a significant difference in conveying the intended message.

Research Question 3: Does the use of electronic writing supports by PWA decrease the composition time of personal email messages? Data on each of the participant's composition time per total number of characters typed from each probe was graphed and visually analyzed to determine effectiveness of the use of the training and use of the CogLink email interface. A significant effect was determined to exist if there was a negative change in slope and level of the graphed data between the baseline and the end of the instructional

phase. Percentage of non-overlapping data was also used to determine if the effect was significant.

Research Question 4: Does the use of electronic writing supports by PWA improve the ease of use of personal email? Participants completed an email usage survey pre- and post-treatment and rated questions on a five point scale. Data was collected in the initial and final interviews. Average differences between pre- and post-treatment data for the participants as individuals and as a group were described.

Research Question 5: Does the use of electronic writing support by PWA increase the use of personal email messages? If so, does the increased use of personal email messages decrease feelings of social isolation? Participants reported on personal email use using a five point scale and the data was collected in the final interview. The SAQOL-39 was re-administered during the final interview and compared to the initial SAQOL-39 scores.

Results

Composition and Error Rate for Charlotte

Charlotte was seen for three baseline sessions and two instructional sessions at the UWM Speech and Language Clinic. One post-maintenance session was held in her home, where two writing samples were collected. Charlotte learned to use the CogLink program quickly and did not require any cueing to use it by the end of the first instructional session. She achieved criterion of two consecutive trials across two sessions at the beginning of the

second instructional session. There was not a perceptible change in the length of Charlotte's emails from baseline to post-maintenance. Charlotte's responses to the writing probes averaged 4.33 words and 19 characters with a composition rate of 8.37 seconds per character during the baseline phase, 3 words and 14 characters with a composition rate of 7.86 seconds per character during the intervention phase, and 3.5 words and 15.5 characters with a composition rate of 7.60 seconds per character during the post-maintenance phase (see Figure 2). The slope of the graphed composition rate for Charlotte displayed a downward slope from the baseline phase to the post-maintenance phase. Also, the graphed data had a percentage of non-overlapping data of 100 (i.e., 0% overlapping).

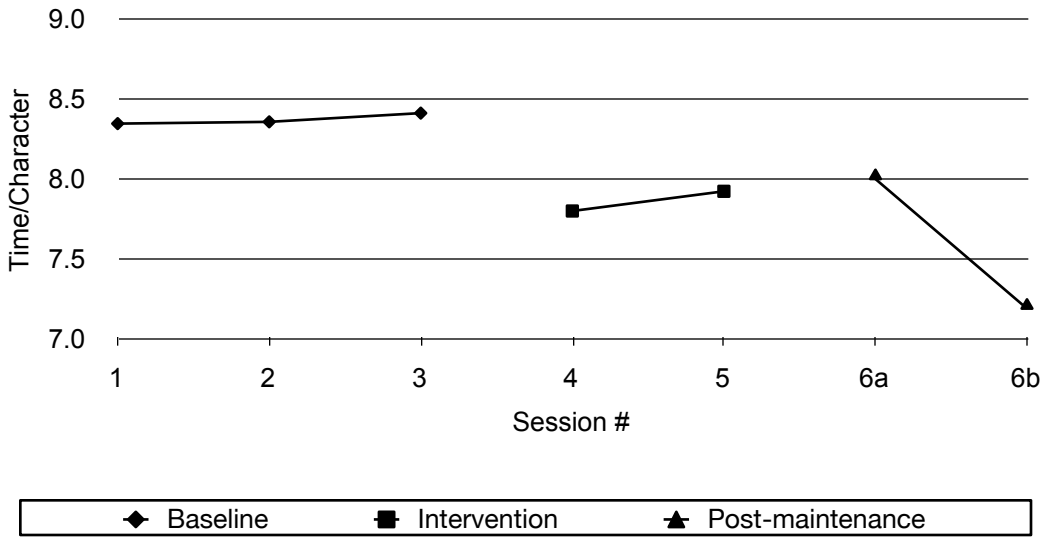

Figure 2: Seconds per character for each writing probe per session for Charlotte.

As demonstrated in Figure 3, Charlotte's rate of errors did not change from baseline to intervention or post-maintenance. The percentage of non-overlapping data was 0. (i.e., 100% overlapping). During baseline writing

samples, the error rate was inconsistent, ranging from 0.25 errors per word to 1.00 errors per word. There were no spelling errors in the baseline phase, but semantic, morphologic, and syntax errors were present (see Table 4 for a breakdown of errors). For example, in response to the probe “Your friend has a small family. Describe your family to your friend.”, Charlotte wrote “family was 3 brother and sister.” During the intervention phase there was one spelling, one morphologic, and one syntax error with error rates of 0.67 and 0.33 for each writing sample. During the post-maintenance phase, morphologic and semantic errors occurred with error rates ranging from 0.50 to 0.65.

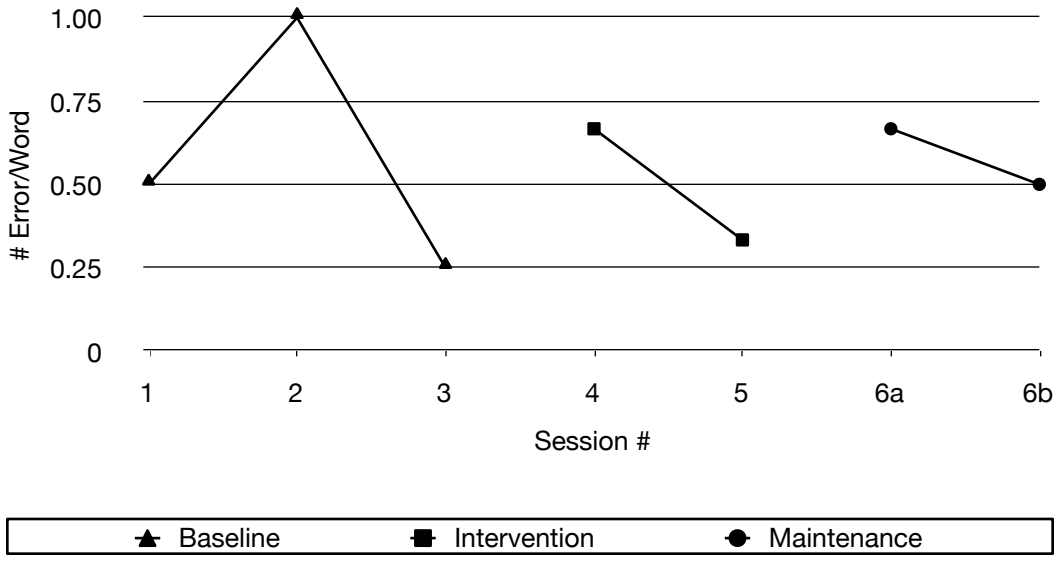

Figure 3: Number of errors per word for each writing probe for Charlotte.

Table 4

Charlotte: Errors per writing probe

	# Words	Spelling	Morphologic	Semantic	Syntax
Baseline					
1	6	0	3	0	0
2	3	0	1	1	0
3	4	0	0	0	0
Intervention					
4	3	1	1	0	0
5	3	0	0	0	1
Post-Maintenance					
6a	3	0	2	0	0
6b	4	0	1	0	1

Composition and Error Rate for Emily

Emily was seen for one baseline session at the UWM Speech and Language Clinic. Four baseline sessions, two instructional sessions, and one post-maintenance session were held in her home. Two writing samples were collected during the post-maintenance session. Emily also learned to use the CogLink program quickly. She achieved criterion in 3 instructional sessions. Emily's responses to the writing probes averaged 9 words and 32.8 characters with a composition rate of 4.52 seconds per character during the baseline phase, 5 words and 17.5 characters with a composition rate of 4.05 seconds per character during the intervention phase, and 6.5 words and 22.5 characters with a composition rate of 4.13 seconds per character during the post-maintenance phase (see Figure 4). Composition rates for Emily appeared to decrease slightly from the baseline phase to the post-maintenance phase. The percent of non-

overlapping data was 100%. See Table 5 for a comparison of mean composition rates during each phase by Charlotte and Emily.

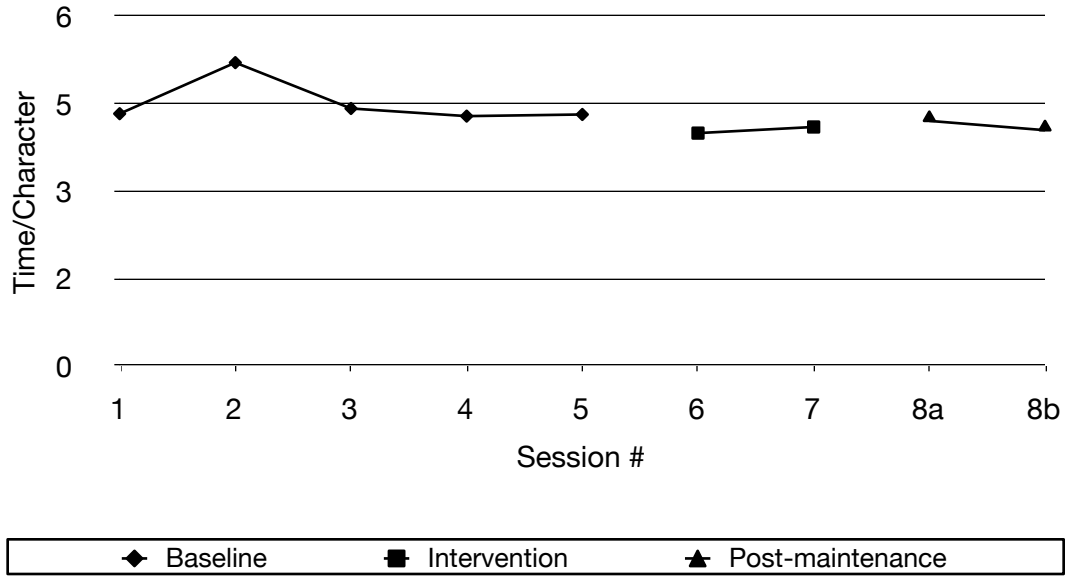

Figure 4: Seconds per character for each writing probe per session for Emily.

Table 5

Mean Composition Rates of Writing Samples in Seconds per Character

	Baseline	Intervention	Post-maintenance
Charlotte	8.37	7.86	7.60
Emily	4.52	4.05	4.13

Emily's rate of errors did not change significantly from baseline to intervention or post-maintenance (see Figure 5). The percentage of non-overlapping data was 0. (i.e., 100% overlapping). Throughout the baseline phase, there was one email message out of 5 with a single semantic error with an overall error rate of 0.13 errors per word. The remaining 4 email messages

composed during the baseline phase were without errors. During the intervention and post-maintenance phases one spelling error occurred for an error rate of 0.20 errors per word (see Table 6).

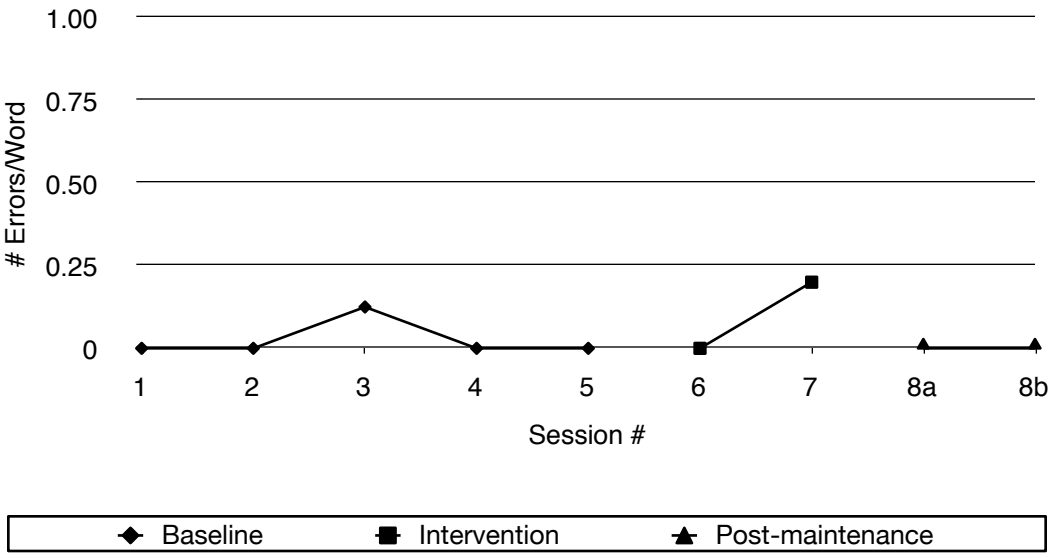

Figure 5: Number of errors per word for each writing probe for Emily.

Table 6

Emily: Errors per writing probe

	# Words	Spelling	Morphologic	Semantic	Syntax
Baseline					
1	8	0	0	0	0
2	9	0	0	0	0
3	8	0	0	1	0
4	13	0	0	0	0
5	7	0	0	0	0
Intervention					
6	5	0	0	0	0
7	5	1	0	0	0
Post-maintenance					
8a	6	0	0	0	0
8b	5	0	0	0	0

Ease of Understanding of Messages by Charlotte and Emily

Unfamiliar readers rated pre-intervention messages as easier to understand with an average rating of 4.17 on a 5-point rating scale than the post-intervention messages with an average rating of 2.2 (see Table 7). A paired samples t-test was significant with $t(9)=12.078$, $p<.001$. .

Unfamiliar readers rated Emily's post-intervention messages as easier to understand with an average rating of 4.55 on a 5-point rating scale than the pre-intervention messages with an average rating of 3.98. A paired samples t-test was significant with $t(9)=-2.967$, $p=.016$. See Table 7 for a comparison of the ease of understanding ratings by unfamiliar readers for Charlotte and Emily.

Table 7

Average Rating by Unfamiliar Readers for Charlotte and Emily During Each Phase

	Baseline	Intervention	Post-maintenance
Charlotte	4.17	2.4	2.2
Emily	3.92	3.80	4.55

Quality of Life Survey Results for Charlotte and Emily

There was a slight improvement in Charlotte's pre- and post-SAQOL-39 mean scores due to gains in the Physical Score and the Communication Score (see Table 8). However, there was a negative change in feelings of social isolation represented by the Psychosocial Score on the SAQOL-39. While there were modest changes in the scores, the reported

changes were not significant. All post-maintenance scores were within the range of standard deviation from the pre-intervention test scores.

Table 8
Pre/Post SAQOL-39 and Email Usage Results

Participant		*Charlotte*			*Emily*		
		Pre	*Post*	*Change*	*Pre*	*Post*	*Change*
SAQOL-39 (Stroke and Aphasia Quality of Life Scale)	SD (+/-)						
Mean Score	0.70	2.7	3.08	0.36	4	4.18	0.15
Physical Score	0.98	2.3	3.12	0.83	4.7	4.82	0.11
Communication Score	0.88	2.3	2.89	0.60	3.7	4.00	0.29
Psychosocial Score	0.86	3.5	3.09	-0.36	3.5	3.55	0.10
Energy Score	1.09	3.3	3.25	0.00	3.3	3.00	-0.25
Email Usage Survey		1.4	3.63	2.25	3.1	3.50	0.37

Email Usage Survey Results for Charlotte and Emily

Over the course of the study Charlotte's mean email usage score improved over the course of the study from a 1.38 to 3.63 on a five point scale. Pre and post mean email usage scores for Emily went from a 3.13 to a 3.50 on a five point scale (see Table 8). During the final interview, Charlotte reported that she was using email more frequently now than prior to the study. However, the use of CogLink only slightly increased the use of personal email for Emily per self-report.

Discussion

Research Question 1: Does the use of an adapted email program with electronic writing supports for PWA decrease the error rate in personal email messages? What types of errors remain, if any?

While composing email messages on the standard email package, Charlotte was able to recognize errors in syntax, and semantics, but was unable to independently edit her messages. Using the simplified email package, Charlotte recognized spelling, syntax, and semantic errors, and could occasionally correct spelling errors independently. The simplified email package did not appear to assist her in editing syntax or semantic errors. Charlotte had the most difficulty with syntax errors and made few spelling errors. When semantic errors did occur, Charlotte was able to recognize the errors, but was often unable to correct these errors independently. She was frequently unable to independently move the cursor to the correct location and delete the word or words containing errors. Over the course of the study, there was no identifiable pattern of errors. Charlotte's error rate were inconsistent throughout the study, thus no treatment effect could be attributed to the effects of using the modified email program.

Emily exhibited only one error across her baseline sessions, thus there was no room to decrease error rate even with writing support. Emily was able to independently identify and correct all but two errors throughout the study. While composing email messages in both the standard and simplified email packages,

Emily was able to independently identify and correct most spelling, syntax, and semantic errors.

Error rates in the writing samples for both participants remained unaffected. There are several possible explanations for this result. The short intervention period may have contributed to the lack of change in error rates. Possibly, using supports for a more extended period of time would result in greater changes due to greater familiarity and efficiency in using the writing support tools. The specific nature of language impairment of each PWA may have also influenced error rate. While the adapted program helped simplify the procedure of sending email, the underlying linguistic deficits remained. Charlotte was often unable to edit and revise errors, while Emily was able to successfully edit and revise her messages. The text-to-speech tool may have been helpful in identifying errors, but not correcting them. Thus, editing skills may be more influential in determining error rates. Finally, in this study no writing treatment was administered, rather the use of an email program was taught. Therefore, participants may benefit from language intervention targeting writing skills.

Research Question 2: Does the use of an adapted email program with electronic writing supports for PWA increase the comprehensibility of personal email messages as judged by unfamiliar readers?

Charlotte's messages from baseline phase were rated easier to understand than those she composed in post-maintenance. This may be due to the fact that while the CogLink helped to increase composition rates and ease of

email usage, the underlying linguistic deficits were still present. Charlotte experienced more errors per word than Emily and error rates were unaffected by the use of the writing supports.

Emily's messages from post-maintenance were rated easier to understand than her baseline messages. The error rate remained low throughout the study and she did report an increase in the ease of use of the CogLink program over her traditional email program. By reducing the cognitive load through the use of the adapted CogLink program, this may have facilitated improved linguistic output.

For both participants it is possible that the linguistic demands required for the responses to the probes used during the post-maintenance phase impacted the comprehension ratings. The prompts were developed to be functional and to allow for a wide range of responses based on personal experience. However, the prompts were not controlled for complexity of response and selected randomly. It may be that the probes given to Charlotte during the post-maintenance phase required a more complex response than those given during the baseline phase. The prompts for Emily may have been less challenging during the post-maintenance phase and more complex during the baseline phase. As both post-maintenance phase writing samples were collected during the same session, the comprehension rates may have been affected by performance fluctuations due to external factors, such as mood and energy level.

Research Question 3: Does the use of an adapted email program with electronic writing supports for PWA decrease the composition time of personal email messages?

Both participants reported that the adapted email program was easier to use than traditional email programs and both participants experienced a decrease in composition rate from baseline to post-maintenance. The effect of writing supports on the composition rate was more pronounced for Charlotte. This was demonstrated by the negative trend of the slope and level of the graphed data. One reason for this result could be that Charlotte demonstrated difficulty with editing and revising her intended message during baseline sessions. The use of the word prediction tool helped her quickly select the intended word. Rather than having to spell out entire words, Charlotte could type the first two or three letters and pick out the intended word from the word prediction tool.

Charlotte had rarely used email after her stroke. The decrease in composition rate could also have been due a practice effect; she wrote email messages more frequently during the study than prior to the study.

Emily was proficient with editing and revising and saw only a modest decrease in composition rate. She only occasionally used the writing tools. Emily reported that the use of the word prediction tool helped to make writing email messages faster to compose, when she had spelling difficulties.

Research Question 4: Does the use of an adapted email program with electronic writing supports for PWA improve the ease of use of personal email?

Both participants liked the simplified layout of the screen and the limited options. The directions and prompts provided in the email program consisted of short sentences and phrases in a larger font size than traditional email programs. These design choices are similar to the recommendations for written information for PWA by Rose et al. (2011). During the final interview Charlotte reported that the word prediction tool helped make email usage faster and less frustrating, because she only had to be able to type a few letters for longer words. The word prediction tool was easier to use than the traditional spell check or the autocorrect feature available on her tablet computer. Charlotte reported that the text-to-speech tool was hard to understand and this tool was not helpful, as did Emily.

While there was an increase in Emily's mean email usage score, it is hard to determine if the increase is significant. Emily did not use the writing supports often, as she was able to identify and revise most errors. When she did have spelling errors, the word prediction tool helped to facilitate revisions per self-report.

Research Question 5: Does the use of an adapted email program with electronic writing support for PWA increase the use of personal email messages? If so, does the increased use of personal email messages decrease feelings of social isolation?

Charlotte reported using email more frequently with the accessible email program. In her exit interview Charlotte reported feeling more confident and excited about using email to communicate with her friends and family. She reported that she will continue to use email following the study. Prior to the study Charlotte rarely used email. Charlotte is not sure whether she will continue to use the PACK drive, but this study has given her the confidence to continue to use email. While Charlotte did write more email messages during the study than she had prior to participating in the study, she experiences some barriers to her use of the Coglink program which interfered with her ability to use the program as much as she would have liked. Initially, Charlotte had trouble getting the program to run properly on her computer. The computer was located in the family room adjacent to the kitchen. Even after the problems with the program were resolved, Charlotte needed assistance getting to the home computer because of her mobility issues. It was observed that Charlotte needed assistance moving the desk chair in order to access the computer while using her wheelchair. In the email usage survey and in the final interview, Charlotte reported that she now uses email more than prior to participation in this study. She plans to continue to use email to communicate with friends and family.

Charlotte suggested that it would be beneficial if CogLink added an improved speech generator.

Charlotte's home computer was equipped with a touchscreen monitor, which was a significant change from the computer set-up used during baseline and intervention. Because of Charlotte's frequent use of a touchscreen tablet computer, she would try to manipulate items on the screen by touching the standard screen during intervention sessions. Charlotte reported that she would use the adapted email program more, if it was compatible with her tablet computer.

While Emily reported that the adapted email program was easier to use than the traditional email package she used prior to participation in this study, she did not use Coglink more. Emily reported that she was able to be more independent using email and was less frustrated than she was when using a traditional email program. Emily did not have to rely on her husband to help her navigate the CogLink program. She was able to independently access the home computer located in a home office. Although there were increases in the SAQOL-39 mean score, physical score, communication score, and psychosocial score; the changes all fall within the standard deviation (see Table 8). In her exit interview and conversations held throughout the study Emily reported that she may use a combination of the CogLink program and her traditional email program. She subscribes to many newsletters and organizations related to her hobbies using her traditional email account and may use the CogLink program exclusively for friends and family.

Although both participants reported that they used email more frequently to write to family and friends during the final interview, this study failed to demonstrate that the use of an accessible email program reduces the feelings of social isolation as indexed with the SAQOL-39.

One possible explanation for this was the duration of the study. Participants were only given three weeks to use the accessible email program with friends and family members. Another possible explanation is that there were other issues impacting the participants' quality of life which were not identified. For instance, depression is a common in people with aphasia, but was not assessed in this study. Finally, the self-reports may reflect a bias, due to the fact that the researcher was also the interviewer.

Duration of Intervention

Using the protocol developed for this study, Emily and Charlotte were able to quickly (two and three session respectively) learn the cognitively and linguistically complex task of independently receiving and sending email. In comparison, three participants with TBI in the longitudinal study conducted by Sohlberg, et al. (2005) required five to nine sessions to learn how to perform the basic CogLink skills independently. It was not clear from the literature how long a fourth participant took to master the basic program skills. This difference in duration to master the CogLink program may be explained by the underlying cognitive differences seen in PWA and individuals with TBI.

Limitations

While this study provides evidence that the use of an adapted email program provides some benefit to individuals with aphasia, there are some major limitations to this study. First, this study included only two participants. A larger sample size may have provided more representative results. It is difficult to say how widely the results of this study apply to other PWA.

A second limitation of this study was the duration of the maintenance phase. Participants used the adapted email program at home for only three weeks. Given more time to integrate the accessible email program and using the writing supports more efficiently may have affected the amount of email usage and effects on the quality of life of participants.

Third, the tool used to measure psychosocial aspects may not have been sensitive enough to changes related to communication. The SAQOL-39 includes 39 questions of which 11 relate to psychosocial issues and only four questions relate to communication. The questions may not have been sensitive enough to capture subtle changes in social participation and feelings of social isolation related to communication. Additionally, participants were not screened for depression.

A fourth limitation entails the lack of a writing assessment. While the study did not target linguistic goals, a writing assessment pre- and post-treatment might have captured changes in participant writing skills.

Finally, technical difficulties during the maintenance phase may have impacted Charlotte's ability to incorporate the use of email into her daily life. She

was unable to address the technical difficulties independently and needed family members to work with the researcher in order to get the PACK drive and Coglink program to function correctly in her home environment. It is possible that Charlotte did not fully embrace the CogLink program even after the technical problems were resolved.

Future Research

While the results were promising, there is much more to be done. A study with a larger sample size would help relate findings to the general population of PWA. The language characteristics of the two participants in this study were categorized as moderate aphasia, as measured by the WAB-R. While not all forms of aphasia may appropriate for inclusion, expanding the study to include other forms of aphasia may help to determine if there is a difference in potential benefit based on aphasia categorization. This study could also be expanded to include individuals with milder severity levels of aphasia. A study comparing moderate and mild aphasia severity levels would help to determine if there is a difference in potential across severity levels. Individuals with one aphasia type and severity level may benefit more from the use of an adapted email program than others.

Additionally, a longitudinal study would give participants more opportunities to apply the use of email to their everyday life and for social participation. Given more time both participants and their communication partners may become more comfortable with electronic communication.

Additional follow-up sessions and extending the post-maintenance phase would give insight into how well participants are able to incorporate the adapted email program into their daily life. It will require a longer term study to identify if PWA can use email as a means to reduce feelings of social isolation.

In future research the issue of technical support must be addressed. It would be beneficial to provide all participants with all of the equipment needed for the study, including the PACK drive as well as a standardized computer, keyboard, and mouse. This would limit the potential for technical difficulty due to hardware differences.

Both participants made suggestions as to how the adapted email program could better suit their needs as PWA. They suggested an improved speech generator, a speech-to-text tool, and a customizable dictionary. For example, a better text-to-speech generator would allow PWA to hear the written words as they read along, which in some individuals may facilitate comprehension. A speech-to-text tool would allow individuals the ability to add words when they found saying a word out loud easier than spelling the target word. A customizable dictionary would allow individuals to add words which are important to their personal daily life (e.g. names of friends and family) and words which are difficult for them to spell. A dictionary with specific and individualized entries would be more functional and could be set up to match a person's specific needs. Future studies could investigate whether specific support tools and features had measurable differences in the facilitation of email production and ease of use. It may be that the use of some supports show more promising

effects in the facilitation of more effective and efficient email communication than the use of other supports.

Including feedback from family, friends, and caretakers in future research would provide information on additional technical and writing supports, design issues, as well as troubleshooting issues. Communication partners would be able to provide a different perspective on changes in ability to understand intended messages and the impact on social participation.

Further studies could also explore the use of email by PWA to send non-linguistic materials such as photographs or drawings in order to facilitate communication. Such a study could investigate whether the incorporation of non-linguistic materials in electronic communication helps PWA convey intended messages more efficiently and effectively by reducing the linguistic demands.

Summary

This study revealed that PWA with moderate aphasia could quickly master a fairly complex multi-step adapted email program. The use of the adapted email program generated modest changes in composition time for both participants. The participants expressed the desire to continue to use email as a means of reconnecting with friends and family. While there was no significant improvement of quality of life scores, both participants reported that the use of the accessible email program and its writing tools improved the ease of email use and positively impacted the participants' life participation goals. This study demonstrated that a small amount of treatment using an adapted email program allowed PWA to

overcome the barriers to using email for social communication. It is therefore important to further explore the potential of adapted email programs to meet the specific life-participation goals of PWA.

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Appendix A

CogLink Email - Detailed Instructions

Plug In

"Here are the directions for the PACK drive and the email program. You can use this sheet to help you. Now I will show you how to use this device. (show PACK drive) This is the PACK drive. This will plug into the computer. First we need to open the PACK. To do this push on the button and slide it. (point to the button) The USB plug should be out. This is the USB plug."

"Now we need to plug the PACK into the computer. The PACK fits into a USB port. This is the right port, here. (point to port) Here is a picture of the USB icon (point to a larger picture of the icon on the Instructions Handout). This will show you which port is the right one. Now plug the PACK into the USB port."

Open

"On the screen you now see the PACK drive icon (point to icon). Using the mouse, double click on the PACK icon. Now wait. The PACK drive will open up. It may take a few minutes. Do not click the mouse again. Wait patiently."

"Now that the PACK system is open, we can open up email. To open up email, click the email button. (point to button) Now you are ready to use email."

Orientation to Screen

"On the left side is where you will find the names of your contacts (point to contact list). You can send them email and they can send you email. No one else can send you email. People can be added to this list."

Read

"The green area is for reading email (point to green area)." When you have a new email, the words 'New Mail' will be next the name of the sender. (point to the words 'New Mail') To read a message, click on the name next to 'New Message.' The email message will open. You can read the email in the green area. Above the green area is the date they sent the message and the subject of the email."

Word Choices

"Now we will learn about the word choice feature. First we need to open a new message. Click on the name Anne Sempos. (point to name) Then click on the Reply button to open a blank message screen. (point to Reply button) Now we will talk about the word choice feature. The word choices feature will try to guess what word you are typing. When you are typing, the program will try to guess which word you want. Now type these letters: e-m-a. We are trying to type the word 'email'. The word choice feature has come up with a list of possible words. (point to the word list) Here is the word email. (point to the word email) To pick the word you want, click in the box next to the word you want. (point to the box). Now click this box. See how that worked? Now type the letters m-e-s. We are trying to type the word 'message.' Here is the word

‘message.’ (point to the word ‘message‘) To pick this word, click in the box next to the word. (point to the box).

If you do not want to use this you can click the cancel button.”

Read-Back

“Next we are going to talk about the Read-Back tool. This tool reads the email messages out loud. First we need to open up an email message. Click on my name to read the message I sent. (point to Anne Sempos). The message is now open. To have the computer read the message to you, click on the Read button. (point to the Read button)

You can also listen to the messages you type. Click on the Reply button (point to the button). Now type this message: ‘I like email.‘ To listen to your message, click on the read button. (point to the button)”

Send

“You can also send email messages. To send an email, first click on the name of the person you want to send an email to. Now click on the name, Anne Sempos. (point to the name button) To start a new message, you need to click the Reply button at the bottom of the screen. Now click on the Reply button. (point to Reply button)

Now you can type your email in the pink area. (point to pink area) Here is a sample message. Type this message (‘Hello’). The message is finished. Now click the Send button to send the email. (point to the Send button)”

Exit

“When you are finished with email you need to quit the PACK drive. To quit email, click on the Quit button. (point to the button) You will go to the Home Screen. Click on Close Pack. (point to the Close PACK button) Now the PACK drive is closed. You can now take the USB drive out of the computer.”

“Now, let’s try that again.” (Repeat Detailed Instructions 2 times before moving to Probing for Independent Use)

Appendix B

CogLink Email Instructions Handout

Plug In

Slide the USB out.

Plug into a USB port on the computer.

This is what the USB icon looks like. 

Open PACK

Double click on the PACK icon.

Open Email

Click on the email button.

Read

Click on the name of the sender.

Word Choices

When you type a word the program will try to guess which word you want.

To pick the word you want, click in the box next to the word you want.

Read-Back

Click the **Read** button, to have the computer read the message.

Send

Click on the name of the person you want to send an email to.

Type your email in the message box.

Click the **Send** button

Exit

Click the **Quit** button.

Click on **Close Pack**.

Unplug the USB drive.

Appendix C

Stroke and Aphasia Quality of Life Scale

(SAQOL-39; Hilari, Byng, Lamping, & Smith, 2003)

The first set of questions ask about how much trouble **you have had with daily activities.**

DURING THE PAST WEEK **How much trouble** did you have:

Item ID		Couldn't do it at all	A lot of trouble	Some trouble	A little trouble	No trouble at all
SC1.	Preparing food?	1	2	3	4	5
SC4.	Getting dressed?	1	2	3	4	5
SC5.	Taking a bath or shower?	1	2	3	4	5
M1.	Walking? (if you cannot walk circle 1 and go to item M7)	1	2	3	4	5
M4.	Keeping your balance when bending over or reaching?	1	2	3	4	5
M6.	Climbing stairs?	1	2	3	4	5
M7.	Walking without stopping to rest? or Using a wheelchair without stopping to rest?	1	2	3	4	5
M8.	Standing?	1	2	3	4	5
M9.	Getting out of a chair?	1	2	3	4	5

Item ID		Couldn't do it at all	A lot of trouble	Some trouble	A little trouble	No trouble at all
W1.	Doing daily work around the house?	1	2	3	4	5
W2.	Finishing jobs that you started?	1	2	3	4	5
UE1.	Writing or typing, i.e. using your hand to write or type?	1	2	3	4	5
UE2.	Putting on socks?	1	2	3	4	5
UE4.	Doing buttons?	1	2	3	4	5
UE5.	Doing a zip?	1	2	3	4	5
UE6.	Opening a jar?	1	2	3	4	5

The next set of questions ask about **how much trouble** you have had **communicating** with other people

DURING THE PAST WEEK **How much trouble** did you have:

Item ID		Couldn't do it at all	A lot of trouble	Some trouble	A little trouble	No trouble at all
L2.	Speaking?	1	2	3	4	5
L3	Speaking clearly enough to use the telephone?	1	2	3	4	5
L5.	Getting other people to understand you?	1	2	3	4	5
L6.	Finding the word you wanted to say?	1	2	3	4	5
L7.	Getting other people to understand you even when you repeated yourself?	1	2	3	4	5

The next part is about **problems** or **feelings** that some people have after their stroke.

DURING THE PAST WEEK Did you:

Item ID		Definitely yes	Mostly yes	Not sure	Mostly no	Definitely no
T4.	Have to write things down to remember them? or if you cannot write: Have to ask somebody else to write things down for you to remember?	1	2	3	4	5
T5.	Find it hard to make decisions?	1	2	3	4	5
P1.	Feel irritable?	1	2	3	4	5
P3.	Feel that your personality has changed?	1	2	3	4	5
MD2.	Feel discouraged about your future?	1	2	3	4	5
MD3.	Have no interest in other people or activities?	1	2	3	4	5
MD6.	Feel withdrawn from other people?	1	2	3	4	5
MD7.	Have little confidence in yourself?	1	2	3	4	5
E2.	Feel tired most of the time?	1	2	3	4	5

Item ID		Definitely yes	Mostly yes	Not sure	Mostly no	Definitely no
E3.	Have to stop and rest often during the day?	1	2	3	4	5
E4.	Feel too tired to do what you wanted to do?	1	2	3	4	5

The next set of questions ask about your **family** and **social life**

DURING THE PAST WEEK Did you:

Item ID		Definitely yes	Mostly yes	Not sure	Mostly no	Definitely no
FR7.	Feel that you were a burden to your family?	1	2	3	4	5
FR9.	Feel that your language problems interfered with your family life?	1	2	3	4	5
SR1.	Go out less often than you would like?	1	2	3	4	5
SR4.	Do your hobbies and recreation less often than you would like?	1	2	3	4	5
SR5.	See your friends less often than you would like?	1	2	3	4	5
SR7.	Feel that your physical condition interfered with your social life?	1	2	3	4	5
SR8.	Feel that your language problems interfered with your social life?	1	2	3	4	5

Appendix D

Writing Prompts

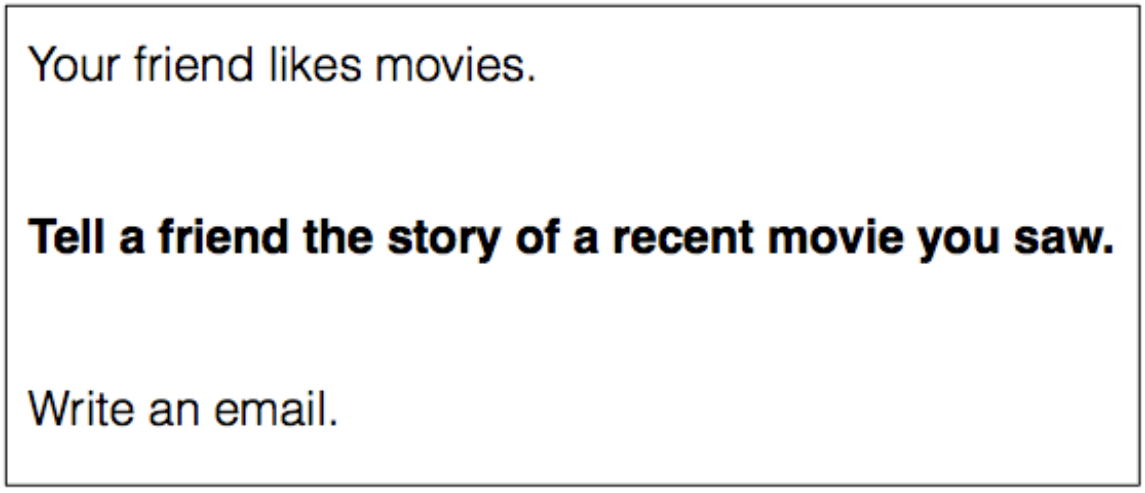
1. Your friend wants to see a movie. Share the story of a recent movie you saw.
2. Your friend is going out for Chinese food. Describe your favorite kind of food.
3. Your friend is planning a trip. Describe your favorite place to visit.
4. Your friend likes to watch tv and movies. Explain why you like your favorite tv show or movie.
5. Your friend is a teacher. Describe a favorite teacher of yours.
6. Your friend wants to go to a basketball game. Explain why you like your favorite sport.
7. Your friend is coming to visit Milwaukee. Describe your favorite thing to do in Milwaukee.
8. It is your friend's birthday. Describe a special event or birthday.
9. It is almost Thanksgiving. Describe what you like to do on Thanksgiving.
10. Your friend enjoys the Fall season. Explain why you like your favorite season.
11. Your friend wants to move. Describe what you like about where you live.
12. Your friend is looking for a new job. Describe what you did for a living.
13. Your friend has a small family. Describe your family to your friend.
14. Your friend is buying a gift for his sister. Describe a favorite gift you received.
15. You are going out to eat. Explain why you like your favorite place to eat.
16. Your friend just got her first email address. Explain what you like about email.
17. Your friend asked what you did yesterday. Describe what you did yesterday.
18. It is almost winter. Describe what you enjoy doing in the winter.
19. It is almost spring. Describe what you enjoy doing in the spring.

Appendix E

Writing Prompt Presentation

Prompt will be presented orally and in writing. The prompt may be read a maximum of three times. Participants will have access to the written prompt during while writing.

“I want you to write an email to a friend. You have as much time to write as you need.”



Appendix F

General Information Form: Participants with Aphasia

(adapted from Ohio University)

Birth date: Age:

Gender: M / F Handedness: right left

1. Are you a native speaker of English? Y / N
2. Have you ever had a learning/developmental/language disability? Y / N
3. Have you ever had a traumatic brain injury? Y / N
4. How many strokes have you had?
   - What are the dates of each stroke you have had?

1. How is your overall health?

2. Do you have any serious illnesses or diseases? Y / N
   - if yes, please describe

3. What is the highest level of education you obtained?
4. Which hand did you use to write, prior to your stroke? R / L
5. Are you currently taking any medications? Y / N
6. Do you have any hearing problems? Y / N
   - If yes, please describe.

   - hearing aid R / L
7. Do you have any visual problems? Y / N
   - If yes, please described. glasses / contacts

8. Do you have a history of any of the following?
   - ☐ strabismus (deviant eyes, cannot be directed to the same object simultaneously)
   - ☐ amblyopia (poor vision or dimness of vision, for which there is no apparent pathology)
   - ☐ glaucoma (increased intra ocular pressure resulting in atrophy of the optic nerve)
   - ☐ cataracts (development of an opaque film on the eye)
   - ☐ retinal problems (retinal detachment or macular degeneration, for example)

- ☐ past and/or present ocular problems
- ☐ laser treatments or other eye operations

If so, please describe.

1. Do you experience any of the following types of visual discomfort?
   - ☐ eyestrain
   - ☐ pulling
   - ☐ pressure
   - ☐ fullness
   - ☐ frequent headaches or muscle tension
   - ☐ itching
   - ☐ dryness
   - ☐ burning
   - ☐ grittiness / foreign body sensation
   - ☐ tearing
   - ☐ blind spots
   - ☐ halos / rainbow-like fringes
   - ☐ heightened sensitivity to light
   - ☐ double vision (horizontal or vertical?)
   - ☐ floaters / flashing lights / hallucinations
   - ☐ other

1. Do you have difficulty understanding what others are saying?
   - If yes, please describe.

1. Do you have difficulty finding words to express what you want to say? Y / N
   - If yes, please describe.

2. Do you have trouble speaking? Y / N
   - If yes, please describe.

3. Do you have trouble moving your arms, legs, or trunk? Y / N
   - If yes, please describe.

Appendix G

Computer Use Interview Questions

(adapted from Sohlberg, Ehlhardt, Fickas, & Sutcliffe, 2003)

1. Did you use a computer prior to your stroke? Y / N

Yes	
☐ news	☐ music
☐ email	☐ shopping
☐ word processing	☐ paying bills
☐ games	☐ finding information
☐ tv, videos, or movies	☐ facebook, twitter, etc.
☐ other:	

2. Have you used a computer following your stroke? Y / N

Yes	**No**
☐ news	☐ financial
☐ email	☐ motor problems
☐ word processing	☐ visual problems
☐ games	☐ hand-eye problems
☐ tv, videos, or movies	☐ too complicated
☐ music	☐ takes too long
☐ shopping	☐ feel intimidated
☐ paying bills	☐ not interested
☐ finding information	☐ other:
☐ facebook, twitter, etc.	
☐ other:	

3. Why are you interested in using/learning to use email now?

4. Do you currently own a computer? Y / N
   if no - Do you have access to a computer? Y / N

5. Are you able to read a short, type-written note? Y / N

6. Is there someone available to help you use a computer, if you need it? Y / N

Appendix H

Email Usage Survey

How much trouble do you have:	Can't do it at all	A lot of trouble	Some trouble	A little trouble	No trouble at all
writing an email message	1	2	3	4	5
writing what you want to say	1	2	3	4	5
spelling words correctly	1	2	3	4	5
using spellcheck	1	2	3	4	5
sending email messages	1	2	3	4	5

How often do you:	Not at all	Rarely	Occasionally	Frequently	Every day
write email messages	1	2	3	4	5
receive email messages	1	2	3	4	5
check email	1	2	3	4	5

Appendix I

Probing for Independent Use of PACK Drive

“Here are the directions for the PACK drive and the CogLink program. You may use it to help you. Now I want you to show me how you open up the PACK drive. Now send me (Anne Sempos) this email ‘Hello.‘ Now close CogLink and the PACK drive”

If they can successfully send an email, probe for independent use of the word prediction tool. If the participant is unable to independently able to send an email, provide necessary level of cueing, before moving on the read-back and word prediction task.

“Now I want you to show me how you open up the PACK drive and open the new message. Use the read-back tool to have the computer read the message. Now reply to the message. In the message box, use the word choice feature to select the word ‘computer.’“

Appendix J

Final Interview

1. For what purposes did you use the PACK?

- ☐ email
- ☐ internet
- ☐ games
- ☐ tutorial

1. How did this email program compare to a typical email program?

2. What did you like about the PACK drive?

3. What did you not like about the PACK drive?

4. Do you think you will continue to use email to communicate with friends and family? Why or Why not?

5. Do you think you will continue to use the PACK drive? Why or Why not?

6. Do you think coming to UWM and working with me has helped you improve your email writing?

7. Was this study worth your time?

Appendix K

Comprehension 5-Point Rating Scale

1	2	3	4	5
I did not understand this message at all.	I understood this message a little.	I understood some of this message.	I understood most of the message.	I understand this message perfectly.