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## Communication Bridge: A pilot feasibility study of Internet-based speech-language therapy for individuals with progressive aphasia

Emily J Rogalski, PhD<sup>1</sup>, Marie Saxon, MS<sup>1</sup>, Hannah McKenna, BA<sup>1</sup>, Christina Wieneke, BA<sup>1</sup>, Alfred Rademaker, PhD<sup>2</sup>, Marya E. Corden, MPH<sup>3</sup>, Kathryn Borio, MS, CCC-SLP<sup>4</sup>, M.-Marsel Mesulam, MD<sup>1,5</sup>, and Becky Khayum, MS, CCC-SLP<sup>4</sup>

<sup>1</sup>Cognitive Neurology and Alzheimer's Disease Center, Northwestern University Feinberg School of Medicine (NU FSM), Chicago, IL

<sup>2</sup>Department of Preventive Medicine, NU FSM, Chicago, IL

<sup>3</sup>Center for Behavioral Intervention Technologies, NU FSM, Chicago, IL

<sup>4</sup>MemoryCare Corporation, Aurora, IL

<sup>5</sup>Department of Neurology, NU FSM, Chicago, IL

### Abstract

**INTRODUCTION**—Individuals with aphasia symptoms due to neurodegenerative dementia are under-referred for speech-language therapy (SLT) services. We sought to determine the feasibility of utilizing telepractice, via Internet video conferencing, to connect an individual with progressive aphasia due to dementia to a speech-language pathologist for treatment.

**METHODS**—Participants received an Initial Evaluation, 8 person-centered Internet-based SLT sessions and two Post-Therapy Evaluations. The feasibility of providing web-based SLT, strategies used and their compliance, functional gains and the duration of benefit were assessed.

**RESULTS**—Thirty-four participants from 21 states and Canada were enrolled. Thirty-one participants completed the 6-month Evaluation. Speech-language pathologist-assessed and self-reported functional gains, as well as increased confidence in communication were documented at 2-months and maintained at 6-months post-enrollment.

**DISCUSSION**—Internet-based SLT using person-centered interventions provides a feasible model for delivering care to individuals with dementia and mild/moderate aphasia symptoms who have an engaged care-partner and prior familiarity with a computer.

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**Corresponding Author:** Emily J Rogalski, PhD, Associate Professor, Northwestern University, Cognitive Neurology and Alzheimer's Disease Center (CNADC), 320 E Superior Street, Searle Building 11th Floor, Chicago, IL 60611, 312-503-1155 phone; 312-908-8789 fax, erogalski@gmail.com.

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## Keywords

primary progressive aphasia; Frontotemporal dementia; Alzheimer's disease; speech-language pathology; apraxia of speech

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## 1. INTRODUCTION

Language impairment (aphasia) is a common symptom in clinical dementia of the Alzheimer's type (DAT) and is the defining feature of primary progressive aphasia[1, 2] (PPA). There is currently no cure for DAT or PPA; however, initial research suggests speech-language therapy (SLT) may enhance quality of life (for reviews see[3-5]). Despite positive research, individuals with aphasia due to dementia are under-referred for SLT services[6, 7]. This may be due in part to a lack of evidenced-based data and formal training for speech-language pathologists (SLPs) for providing SLT to individuals with dementia[8]. Additionally, there is the misconception[3, 9, 10] that SLT services are not appropriate for individuals with neurodegenerative syndromes because of its progressive nature and the heterogeneity of language and other cognitive symptoms among individuals. As a result, evidence-based research on the effectiveness of SLT in dementia has been limited to small group and case studies. This study was designed to circumvent both geographic limitations and poor access to care by delivering Internet-based SLT for individuals with aphasia due to dementia through a personalized, interactive, web-application.

The primary goal was to determine if Internet-based delivery of SLT was feasible for individuals with progressive aphasia symptoms. The SLT Intervention focused on three primary areas: 1) impairment-based approaches (i.e., targeting lexical retrieval and motor speech production of personally-relevant words) integrated into a home exercise program; 2) activity/participation strategies to facilitate communication in daily life; 3) disease education, counseling, and care partner training. Home exercises were used to support the Intervention Sessions. Each of these three components occurred throughout the treatment Sessions because this model resembles the clinical setting. Rationale for including these components is supported by previous studies (e.g.,[11, 12]) and by Croot and colleagues[3] who acknowledge that care for individuals with progressive language decline will need to be comprehensive, including combined approaches. The goal of this study is not to determine which component produces better outcomes, but instead is guided by the notion that each component is essential for providing clinical care for individuals with progressive aphasia.

## 2. METHODS

### 2.1 Participants

Thirty-four participants with a clinical diagnosis of dementia due to neurodegenerative disease (e.g., PPA) and prominent aphasia symptoms and their care-partners were enrolled. Participants were required to have a diagnosis of dementia (progressive decline from a prior level in one or more cognitive and/or behavioral domains [e.g., memory, language], to the extent that activities of daily living were impacted) and a prominent aphasia[13]. The root diagnosis of PPA was made on the basis of isolated and progressive language impairment

according to research criteria[1, 2, 14]. Participants provided medical records to confirm the clinical diagnoses.

Care-partners were encouraged to be present during each treatment Session. Three SLPs provided treatment for this study. One SLP was assigned to each participant who completed all SLT Evaluations and treatment sessions. Trained research assistants administered neuropsychological tests, a post therapy interview, and provided technical support.

## 2.2 Standard Protocol Approvals, Registrations, and Patient Consents

Participants were recruited from the Northwestern University PPA Research Program, [Clinicaltrials.gov](https://clinicaltrials.gov), clinical referral and the Cognitive Neurology and Alzheimer's Disease Center (CNADC) website ([www.brain.northwestern.edu](http://www.brain.northwestern.edu)). The Northwestern University IRB approved the study. Written informed consent was obtained from each participant.

## 2.3 Visit Components

Participants received an Initial Evaluation, eight 1-hour Internet video-conference treatment Sessions with an SLP, followed by two Evaluations (2- and 6-month post enrollment) to determine the duration of therapy benefit. Initial and 6-month Evaluations occurred in-person at the CNADC to establish rapport and to complete neuropsychological testing. The 2-month Evaluation and 8 treatment Sessions occurred via Internet video-conferencing.

The Initial Evaluation included three components: 1) informed consent, demographics, neuropsychological testing, and questionnaires (described below); 2) initial SLP evaluation; and 3) an orientation session for the Communication Bridge web-application.

The 2-month Evaluation had 3 components: 1) completion of questionnaires (described below); 2) SLP evaluation via Internet video-conferencing; 3) semi-structured post-therapy interview to assess participant/care-partner satisfaction.

The 6-month evaluation included the same neuropsychological measures and questionnaires as the Initial-Evaluation. Participants also received an assessment by the SLP, which was identical to the 2-month Evaluation, except it was in-person.

**SLP evaluations**—The Initial Evaluation included a review of standardized test scores to determine participant profile of expressive/receptive language strengths and weaknesses; person-centered, structured interview and appraisal of different language domains including the participant's self-reported areas of communication challenge; counseling and disease education provided for the participant and care-partner.

The 2- and 6-Month Evaluations included an assessment of language domains targeted in treatment (e.g., personally-relevant word accuracies); an assessment of which of the recommended strategies the participant was using in daily life via participant and care-partner report; and modifications to strategies and home exercises, based upon the participant's changing needs.

## 2.4 The Communication Bridge Web-application

An important component of the study was the use of the personalized Communication Bridge web-application, developed in collaboration with Northwestern University's Center for Behavioral Intervention Technologies (CBITS; <http://cbits.northwestern.edu/>). An account was created for each participant so that the content of the web-application could be personalized.

Figure 1 shows an example homepage and key features. The "To-Do List", located on the home screen, was updated weekly with SLP-assigned home exercises. The "Watch Page" featured instructional SLT strategy videos to reinforce strategies (e.g., Use of Semantic Circumlocution in Conversation, Practicing Personally-Relevant Words), which were assigned on the participant's weekly To-Do list. Participants clicked a link on the "Calendar" or "Connect" pages to start videoconferencing Sessions.

## 2.5 Treatment approach

The Intervention Session regimen included, impairment-based approaches, activity/participation-based approaches as well as ongoing disease education, counseling and support. These were all personalized to the needs of each participant and family (i.e. person-centered care)[3, 15-17]. Impairment-directed interventions target areas of weakness in a rehabilitation approach to improve function in a specific cognitive domain (e.g., improving lexical retrieval for targeted words). Activity/participation-based interventions, in comparison, aim to increase an individual's ability to participate in desired life activities through the use of compensatory strategies and care-partner training on appropriate cueing techniques (e.g., using a communication wallet). All impairment-based and activity/participation-based interventions utilized in this pilot study were evidence-based interventions that have been previously established for stroke-induced aphasia. During treatment, feedback from both the participant and the care-partner was elicited weekly by the SLP to ensure that strategies were understood and implemented appropriately. Modifications to strategies and further education were provided throughout the course of treatment to ensure care-partners and participants gained independence in implementing the strategies in daily life. Strategies were initially introduced during structured language tasks (e.g., rehearsing a telephone script) and then gradually applied to functional contexts to promote generalization (e.g., using a script during a telephone call). This model of individualized care is consistent with the Life Participation Approach for Aphasia[17-19] and the Care Pathway model[16]. Both of these models recognize the importance of identifying each individual's challenges in order to tailor interventions to their needs. The rationale for our person-centered approach is to maximize impact on the participant's quality of life by teaching strategies that can be implemented in everyday life situations.

After each SLT session, the SLP assigned home exercises. These exercises were listed under the To-Do List (e.g., Figure 1) of the participant's personalized Communication Bridge homepage. Participants were encouraged to practice at least three times per week.

## 2.6 Outcome measures

The outcome measures were administered to each participant allowing for quantification of within-subject gains and comparisons at the group level while providing personalized therapy, which acknowledges the variability of language deficit profiles across participants.

Functional communication was assessed at the Initial-, 2- and 6-month Evaluations with the American Speech-Language-Hearing Association functional communication measures (ASHA-FCM)[20] and the Communication Confidence Rating Scale for Aphasia (CCRSA) [21].

The ASHA-FCM measures the participant's level of functioning for different cognitive-communication domains (e.g. expressive language, writing, etc.), using a 7-point scale, with higher numbers indicating better functioning. This scale corresponds with Medicare claims-based reporting requirements. As in the clinical setting, the SLP identified the participant's most challenging domain in daily life at the Initial Evaluation and appraised their level of functioning for that domain at each Evaluation (i.e., Assessing lexical retrieval accuracies and the level of cueing needed for the Expressive Language domain).

The CCRSA was used to assess confidence, using a 100-point scale (0-not confident, to 100-very confident) in response to 10 questions that address different communication situations (e.g., "How confident do you feel about your ability to talk with family or friends?").

A semi-structured Post-therapy Interview was completed to assess participant and care-partner satisfaction with Internet-based therapy and the web-application and to determine if the treatment had any impact on their quality of life.

For each participant, the therapist documented strategy recommendations, and whether the participant was using the strategies in their daily lives (i.e., compliance) at the 6-month Evaluation. Compliance was determined based on the SLP evaluation as well as self-report from the participant and care-partner. These data were used to determine which therapy approaches were assigned and utilized over time for each participant and if there were gains.

Data will be presented for two of the most commonly recommended interventions: lexical retrieval and motor speech production strategies. For this intervention, the SLP asked participants and their care-partners to identify personally-relevant words that were challenging to retrieve or pronounce in daily conversations. Participants were unable to independently retrieve or accurately pronounce these target words before starting the home exercise program. Participants were encouraged to provide personal pictures of target words rather than stock photos; they could also write a description of the word if no picture was available or if the word wasn't easily represented by a picture. A home exercise program was developed for each participant. The lexical retrieval program focused on use of a hierarchical cueing approach, where a series of semantic, phonological, and orthographic cues were systematically presented until the participant was able to retrieve the target word[22]. For motor speech production, evidence-based interventions utilized for stroke-induced apraxia were applied to promote successful motor sequencing of personally-relevant multisyllabic words. The participant was presented with maximal visual cues for each target

word to promote production (e.g., syllable segmentation, orthographic phonetic cues, in addition to visual/audio cues from a care-partner or recording when needed)[23]. Participants were assigned a lexical retrieval home program, a motor speech home program, or both depending on their symptoms.

A subset of their personally-relevant target words were evaluated by the SLP at the 2- and 6-month Evaluations. For each word either motor speech production lexical retrieval accuracy was assessed. For assessment of lexical retrieval, the SLP provided participants with verbal descriptions of their personally-relevant target words to elicit oral production, and accuracy was determined by whether the individual could independently retrieve the target word, without semantic, phonemic, or orthographic cues being provided by the care partner or SLP. For assessment of motor speech production, the written form of the target word was presented to the participant to elicit an oral production; accuracy was based on intelligibility, measured by whether or not the SLP could accurately understand the word during testing (rather than based upon exact percentage of correct syllables).

## 2.7 Statistical Analysis

Mean scores on the CCRSA across the three time points were analyzed with a repeated measures ANOVA followed by pairwise post-hoc t-tests, with a Tukey adjustment for multiple comparisons. We expected improvement on the CCRSA between baseline and 2-months and maintenance of gains at 6-months. For the ASHA-FCM, we quantified the number of participants who declined, improved or maintained at the 2- and 6-month Evaluations compared to their Initial Evaluation.

In order to determine which strategies might be useful for future interventions for individuals with dementia, the most frequently assigned strategies were identified and their compliance of whether they were being used was tracked (via self-report) at the 6-month Evaluation. Therapy strategy compliance over time was measured for each strategy category (# participants using the strategy at 6-months / # participants assigned the strategy during the treatment Sessions) and summarized as a percentage for each participant.

## 3. RESULTS

Of the 34 participants, 2 discontinued because of severity and 1 due to non-compliance and inadequate computer abilities. Thus, 31 individuals with early-to-mid-stage dementia and their care-partners were included in this analysis (Table 1). All participants were fluent in English. Twenty-seven of the care-partners were spouses, 2 were adult children, 1 was a niece, and 1 was a friend. Participants enrolled from 21 different states and Canada.

### 3.1 Feasibility and functional outcomes

Participant, care-partner and therapist feedback were overwhelmingly positive with 16 participant/care-partner pairs reporting that therapy ‘exceeded’ expectations.

Thirty of the 31 individuals completed the post therapy interview. During the post-therapy interview participants and their care-partners were asked: “If you could change anything about the web-based therapy sessions, what would you change?”. The most common

response was “nothing”, followed by, “add more therapy sessions” (37% and 20% of the participants, respectively).

Expressive language was the most commonly identified domain that was impaired and targeted (n=24/31) in the ASHA-FCM. All participants maintained or improved their level of functioning in their most challenging domain as measured by the ASHA-FCM from the Initial Evaluation to 2-months (65% improved; 35% maintained). At the 6-month Evaluation, only 13% declined by 1 level on the ASHA-FCM compared to the Initial Evaluation.

A repeated measures ANOVA showed significant change in CCRSA scores across the three Evaluations ( $p=0.02$ ). Post hoc t-tests revealed significant improvement in their confidence in communication from baseline to the 2-months (Mean Scores at Baseline=68.2 +/-2.7; 2-months=73.3 +/-2.6;  $p=0.018$ ) and no significant decline at 6-months (Mean Score=70.9 +/-2.9;  $p>0.4$ ).

### 3.2 SLT interventions: gains and compliance

The three most frequent impairment-directed interventions were: 1) Lexical retrieval program for personally-relevant words; 2) Motor speech production program for personally-relevant words; and 3) Script training tasks to facilitate daily conversations (e.g., ordering at a restaurant, describing your condition to others). The three most common activity/participation-directed interventions included: 1) Creation of personalized communication wallets and boards; 2) Functional writing strategies, including use of assistive technology/apps; 3) Auditory comprehension strategies for daily conversations, including participant and care-partner education on how to eliminate environmental distractions and how to increase the use of positive communication strategies (e.g., slowing speech rate, repetition). Table 2 provides descriptions of these strategies. Overall, compliance for the six most commonly assigned strategy categories was good; 74% of those assigned during therapy were still being used at 6-months (Range: 67-83%; see Figure 2 for the percentage of individuals assigned each strategy category and their compliance at the 6-month Evaluation).

Lexical retrieval and/or motor speech production interventions targeting personally-relevant words were assigned for 29/31 individuals, (lexical retrieval alone: 12/31, motor speech production alone: 8/31, both lexical retrieval and motor speech production: 9/31). Participants identified words (range: 10-150 words per participant) that were difficult to retrieve or pronounce during conversation in daily life and the SLP probed accuracy of a subset of these words at the post-treatment Evaluations. Since the number of words targeted and probed (range: 5-47 probed words) differed by participant, the average accuracy was summarized as a percent correct. Average accuracy for lexical retrieval was 87% +/-13 at the 2-month Evaluation and 84% +/-19 at the 6-month Evaluation. Average accuracy for motor speech production was 89% +/-9 at the 2-month Evaluation and 81% +/-13 at the 6-month Evaluation. For participants where both lexical retrieval and production was targeted the average accuracy was 80% +/-17 at the 2-month Evaluation and 90% +/-10 at the 6-month Evaluation (personally-relevant words were not assessed for one participant at 6-months).



## 4. DISCUSSION

This pilot study used a novel Internet-based delivery of speech-language therapy strategies and dementia education for individuals with progressive aphasia and their care partners. The feasibility of using the Internet to connect an individual with a dementia diagnosis to a SLP has rarely been documented in neurodegenerative disease and is currently not reimbursed by Medicare or most health insurance policies. Our results suggest that web-based SLT is feasible and that some statistically significant gains (e.g., in communication confidence) can be made after 8 (weekly) sessions. Therapy reached participants in 21 states and Canada, highlighting that an Internet-based model of therapy has the potential to improve access to care.

Our focus on functional goals is desirable because it allows for the inclusion of individuals with different language deficit profiles (e.g., naming, grammar deficits) and levels of symptom severity and identifies optimal strategies according to the participant's communication strengths and weaknesses. It also allowed us to gain experience with the delivery of the Internet-based intervention among participants with progressive aphasia. One challenge with this model is it makes it difficult to isolate which treatment strategy is contributing to functional gains. Several participants reported improvements in completing functional daily tasks they had abandoned. Scripts enabled one participant to order food at a favorite restaurant. Another participant was able to generate her own paper To-Do list with the use of assistive speech recognition technology to aid with spelling. Systematic assessment of functional gains in daily life may be an important quantitative measurement for future studies.

Results from this pilot study are consistent with preliminary reports indicating that speech language therapy strategies are useful for individuals with dementia (e.g.,[25-31]). Participants with different language deficit profiles as well as individuals with mixed or unclassified dementia diagnosis were able to participate and benefit from SLT, suggesting this approach may be useful across dementia phenotypes. The most severe participant in this study discontinued participation, suggesting that web-based SLT may be most feasible for mild- or moderate-stage dementia.

Evidence-based approaches traditionally used for stroke aphasia or speech apraxia were modified and helpful irrespective of the clinical language profile. For example, elements from Rosenbeck's[23] treatment approach were used to successfully facilitate pronunciation of personally-relevant multi-syllabic words for individuals with an agrammatic profile displaying motor-sequencing errors, but also for individuals displaying phonological errors.

Many participants reported they enjoyed working on their home exercises. The care-partner of a participant who practiced their personally-relevant words almost daily reported at the 2-month Evaluation: *"I really did see an improvement in those words..."* referring to the personally-relevant words. "Overall compared to where he was, it's better. I think that his speech impairment, the way it was going, I think this halted it. Today compared to 6 months ago, he's better." It will be important to identify whether the frequency with which individuals practice their home exercises influences outcomes.



Several participants provided unsolicited feedback that the strategy videos available on the web-application were helpful, with over 600 views among participants. One participant reported the videos were particularly useful for home exercises with several steps because “it was easier to recall the details of the exercise with the videos”. Another participant used the “How to create a communication book” video to successfully create a communication notebook 10 months after their last Session. Systematic tracking of video views and usage by participant may be useful to determine if they promote increased functional gains.

An advantage of web-based SLT was the flexibility of location. SLT could occur anywhere with strong Internet, avoiding logistical challenges (e.g., transportation, geographic) associated with an outpatient clinic. Several participants completed sessions while on vacation (e.g., Europe, Hawaii). Likewise the therapist completed sessions when she had a cold because there was no risk of spreading germs.

Our web-based SLT program had some limitations. Video/audio quality was sub-optimal in some sessions. Increasing Internet speed and/or using a hardline connection resolved most of these issues. Having prior familiarity with a computer was essential. During the course of the study, we implemented a brief technology screening, which helped to identify participants with adequate computer skills for participation.

As a first step to determine feasibility of providing personalized web-based care, a within-subject design and outcome measures that were common across the group was used rather than a randomized control design. In future trials it will be important to document gains from the participants, their therapists and blinded raters to minimize bias and also to establish a stable baseline for all personally-relevant target words. Use of an appropriate control condition in future studies will help disentangle whether the gains reported here are due to the intervention or increased stimulation and engagement.

Care-partner participation was common (77% [n=24/31] of the care-partners were consistently present at the Intervention Sessions). However, their level of engagement varied. SLPs commented that actively engaged care-partners were beneficial to treatment. Systematic ratings of the level of care-partner engagement in the treatment may be an important variable to include in future trials, since it may influence outcomes. The SLPs reported that at times participants and/or their care-partners became emotional/tearful during sessions and felt that the inability to provide a consoling personal touch was a limitation to web-based SLT.

In the absence of a cure for neurodegenerative diseases it is important to offer interventions that help individuals maintain an optimal quality of life and full life participation for as long as possible. Data from this study suggests Internet-based SLT using person-centered impairment-directed and activity/participation-based interventions as well as disease education provides a feasible method for improving access to care for individuals with mild/moderate aphasia symptoms who have an engaged care-partner and prior familiarity with a computer. Improving access to speech language therapy care is important since it may contribute to prolonging the period of independence for the individual with a dementia diagnosis and decrease care-partner burden.

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## Research In Context

### Systematic review

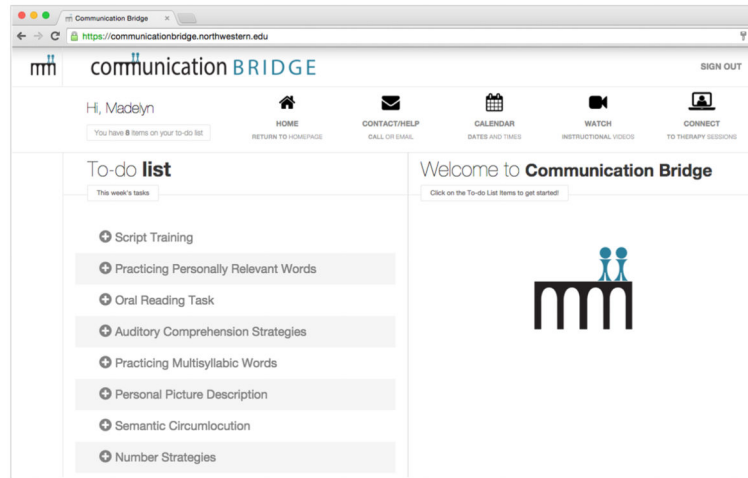
The existing literature was reviewed (e.g., PubMed, Google Scholar) and is cited in the manuscript. Most speech-language therapy (SLT) studies for individuals with dementia have been case or small group reports and none provide SLT over the Internet.

### Interpretation

Our results provide initial evidence that person-centered Internet-based speech-language therapy is feasible for improving access to supportive services for individuals with mild/moderate aphasia symptoms due to dementia who have an engaged care-partner and prior familiarity with a computer.

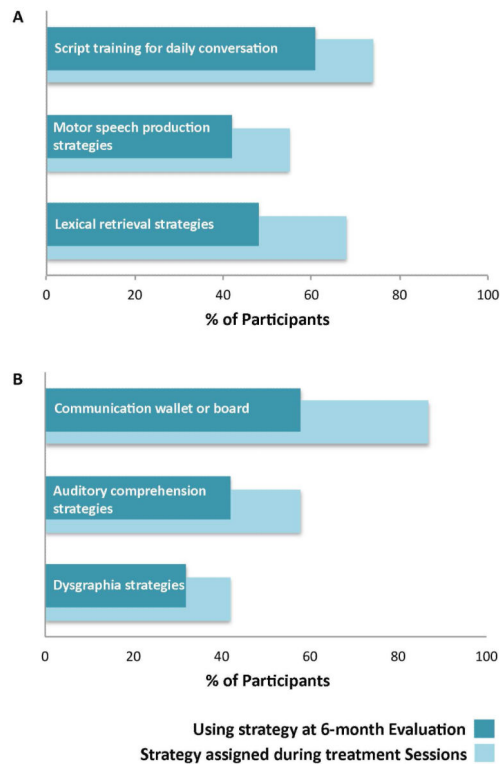
### Future directions

A substantial to-do list remains and includes a randomized controlled trial. Collectively these data can be used to create guidelines for best practices in intervention and management for individuals with dementia.



Key Features of the Communication Bridge Website			
To-Do List	Calendar Page	Watch Page	Connect
Participants can view and complete their weekly home exercise assignments.	Participants can see when their next therapy session, evaluation, or study visit is scheduled.	Participants can watch up to 20 instructional communication strategy videos.	Participants can connect to their online therapy sessions.

**Figure 1. An example of the personalized Communication Bridge web-application homepage (top) and its key features (bottom)**



**Figure 2. The most frequently assigned and used SLT strategies**

A) Percentage of participants assigned and using their impairment-directed strategies at the 6-month Evaluation. Script training was assigned to 23/31 participants and 19 of those participants were still using the strategy at the 6-month Evaluation. Motor speech production strategies were assigned to 17/31 participants and 13 of those participants were still using the strategy at the 6-month Evaluation. Lexical retrieval strategies were assigned to 21/31 participants and 15 of those participants were still using the strategy at the 6-month Evaluation. B) Percentage of participants assigned and using their activity/participation-directed strategies at the 6-month Evaluation. Communication wallets or boards were assigned to 27/31 participants and 18 of those participants were still using the strategy at the 6-month Evaluation. Auditory comprehension strategies were assigned to 18/31 participants and 13 of those participants were still using the strategy at the 6-month Evaluation. Dysgraphia strategies were assigned to 13/31 participants and 10 of those participants were still using the strategy at the 6-month Evaluation.



**Table 1**

Demographic, clinical and neuropsychological characteristics

<b>No. of participants</b>	31	
<b>Age at onset, years</b>	62.5 (6.8)	Range: 53-76
<b>Age at enrollment, years</b>	67.2 (6.9)	Range: 56-83
<b>Gender</b>	Male: 13	Female: 18
<b>Handedness</b>	Right: 30	Left: 1
<b>Education, years</b>	16.1 (2.4)	
<b>Symptom Duration, years</b>	4.3 (2.2)	
<b>Clinical diagnosis</b>	PPA: 28	Other dementia diagnosis: 3
	<b>Initial Evaluation:</b>	<b>6-month Evaluation:</b>
<b>WAB-R-AQ (%)</b>	81.3 (13.9)*	76.7 (17.5)
<b>MMSE (out of 30)</b>	24.1 (5.0)	23.7 (5.5)
<b>BNT (%)</b>	60.9 (29.5)*	54.7 (31.0)

Numbers are provided as means and (standard deviations). Other dementia diagnosis consisted of 1 person with prominent apraxia of speech, one with apathy and aphasia and one with aphasia, working memory and processing speed deficits. Clinician rated aphasia severity is based on the Initial Evaluation. All participants were fluent in English. English was the native language for 29 of the participants. Spanish and Arabic were the native languages for the other two participants. The aphasia quotient from the Western Aphasia Battery Revised (WAB-R-AQ) was used as a global measure of aphasia severity<sup>24</sup>. The Boston Naming Test (BNT) was used to assess the naming of objects<sup>25</sup>. MMSE: Mini Mental State Exam<sup>26</sup>. Because of participant language deficits, a modified multiple-choice version of the MMSE was used for 12 individuals at the Initial Evaluation and 20 individuals at the 6-month Evaluation.

\* Pairwise t-tests indicated significant decline ( $P < 0.05$ ).

**Table 2**

Description of the most commonly used interventions

<b>Impairment-Based Interventions</b>	<b>Description of strategy</b>
<b>Lexical retrieval of personally-relevant words</b>	Participants used personally relevant picture or word-based flashcards to target active encoding of target words. Treatment focused on use of a hierarchical cueing approach, where a series of semantic, phonological, and orthographic cues were systematically presented until the participant was able to retrieve the target word[22].
<b>Motor speech production of personally-relevant words</b>	Participants used paper-based flashcards with orthographic cues to rehearse motor speech production of words that were difficult for them to pronounce. The participant was presented with maximal visual cues for each target word to promote production (e.g., syllable segmentation, orthographic phonetic cues, in addition to visual/audio cues from a care-partner or recording when needed)[23]. Cues were systematically removed as pronunciation improved (i.e., modified version of Rosenbeck's 8-step program).
<b>Script Training for daily conversation</b>	Participants developed written scripts to facilitate speech for specific functional contexts (e.g., answering the phone, describing their condition to friends or strangers, etc.). Scripts were orally rehearsed to increase automaticity in functional contexts.
Activity/Participation-Based Interventions	<b>Description of strategy</b>
<b>Communication Wallets/Boards for daily conversation</b>	Participants created low-tech electronic or paper-based communication aids that were word-based and/or picture-based using personally-relevant stimuli.
<b>Auditory Comprehension Strategies for Daily Conversation</b>	Participants were educated to make environmental modifications (e.g., eliminating environmental distractions). Care-partners received training on increased use of positive communication strategies (e.g., repetition, use of orthographic or picture cues).
<b>Dysgraphia Strategies for Functional Use in Daily Conversation</b>	Participants and care-partners were trained to use paper-based (e.g., pocket dictionary, templates/visual aids) and technology-based (e.g., spell/grammar checks on word processing programs, voice-recognition technology to dictate words to aid in spelling ability, word-prediction technology) supports for functional writing tasks in daily life.