The Thesis Committee for Diana Francisca Cruz
Certifies that this is the approved version of the following thesis:

Video Implemented Script Training in a Spanish-English Bilingual Patient with Aphasia: A Case Study

APPROVED BY
SUPERVISING COMMITTEE:

Supervisor: ______________________________
Maya L. Henry

Co-Supervisor: ______________________________
Elizabeth Peña

Video Implemented Script Training in a Spanish-English Bilingual Patient with Aphasia: A Case Study

by

Diana Francisca Cruz, B.A.

Thesis

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Arts

The University of Texas at Austin

May 2016

Acknowledgements

This thesis would not have been possible without the willingness and industrious personality of my Spanish-English participant with aphasia, RC. Secondly, I would be lost without the combined expertise and knowledge of my principal supervisor Dr. Maya Henry, Stephanie Grasso, and Dr. Elizabeth Peña regarding the assessment and treatment of bilingual individuals with non-fluent aphasia. I would also like to express the deepest appreciation to Rosa Benavidez, Eva Gabriela Gonzales, and Debra Kolton who spent endless hours listening to videotaped treatment sessions to obtain data for the collection of primary and secondary outcome measures. And, finally, I thank my fiancée, Ricardo Cantu, and my parents, for all the caffeine, snacks, and words of encouragement from beginning to end.

Abstract

Video Implemented Script Training in a Spanish-English Bilingual Patient with Aphasia: A Case Study

Diana Francisca Cruz, M.A.
The University of Texas at Austin, 2015

Supervisor: Maya L. Henry
Co-Supervisor: Elizabeth Peña

Purpose: This study examines the utility of a script-based treatment protocol for improving speech production and fluency in a Spanish-English bilingual individual with non-fluent aphasia (RC).

Method: In this single-subject multiple-baseline intervention study, a video implemented script training treatment (VISTA) was designed to facilitate fluent and intelligible speech through training with a visual and auditory speech model. Scripts were rehearsed via synchronized spoken production in daily homework. Treatment sessions with the clinician targeted memorization and conversational usage. Scripts were topics of interest to the participant, tailored for speech rate and level of difficulty based on the participant's habitual rate of speech and motor and linguistic profile. One script in each language contained a high proportion of cross-linguistic cognates to observe potential differences in cross-linguistic generalization. Primary and secondary outcome measures for trained and untrained scripts were percent correct and intelligible scripted words, performance on targets with varying cognate status, errors by word class, total number of grammatical errors, and total percent intelligibility.

Results: RC showed significant improvement in intelligibility and accuracy of trained scripts and a reduction in grammatical errors after treatment. Results revealed that Spanish-trained scripts yielded a larger effect size relative to English-trained scripts. In addition, Spanish-trained scripts displayed a greater degree of unidirectional cross-linguistic generalization to English. Scripts that contained a high proportion of cognates yielded minimal effect sizes relative to non-cognate dense scripts, and in fact dampened cross-linguistic generalization.

Conclusion: Video implemented script training is a viable treatment method for Spanish-English individuals with non-fluent aphasia for improving speech production and fluency. This study also provides evidence that cross-linguistic transfer can be diminished when incorporating tasks with a high proportion of cognates. Future studies should take into account the cognitive-linguistic profile of participants when considering treatment options.

Table of Contents

List of Tables

List of Figures

I. INTRODUCTION

With a major demographic shift underway caused by the United States' rapid transition into a "majority-minority" nation, speech-language pathologists (SLPs) must take into account the diversity of their client base and ensure that interventions and services are culturally and linguistically appropriate (Bernstein, 2012). An estimated 17% of the U.S. total population, or roughly 54 million, are Hispanic/Latino, and 21% of U.S. residents (or 60.6 million people) age 5 years and older speak a language other than English (LaPointe, 2011; U.S. Bureau of the Census, 2013, 2014). In addition, there is a higher prevalence of medical conditions that are risk factors for stroke, including cardiovascular disease, diabetes, and hypertension, in culturally and linguistically diverse populations (LaPointe, 2011). Because stroke is the leading cause of aphasia, evidence-based speech and language interventions are needed to successfully treat the growing number of bilingual adults with stroke-induced aphasias.

Despite this need, existing research regarding cross-linguistic generalization and the most effective form of treatment for bilingual individuals with aphasia is limited. As a result, bilingual aphasia poses a particular challenge for SLPs with regard to choosing the best intervention methods to enable linguistic gains, promote communicative interactions, and enhance social functioning. One barrier to service provision is the critical shortage of bilingual speech-language pathologists to serve the growing bilingual population; only 5% of the 161,163 certified speech-language pathologists identify as bilingual (ASHA, 2014). Clinicians must decide whether it is sufficient to rehabilitate one language or both, and to what extent rehabilitation in one language has beneficial effects in the untreated language (Lorenzen & Murray, 2008).

1.1 THEORIES OF CROSSLINGUISTIC GENERALIZATION

Part of the ambiguity in deciding a primary language of treatment in bilingual speakers can be attributed to the complex system of language processing that promotes language comprehension and production in this population. Several theories have been proposed to clarify how this process works within a bilingual language system (Lorenzen & Murray, 2008; Kirsner, Lalor, & Hird, 1993; Van Heuven, Dijkstra, & Grainger, 1998; Potter, So, Von Eckardt, & Feldman, 1984; Kroll & Stewart, 1994). Early hierarchical models suggest that the bilingual lexical system is structured similarly to that of a monolingual system (Kirsner et al., 1993; Van Heuven et al., 1998). These models implicate a lexical level, which contains information about morphology and syntax, and a conceptual level, which contains information about semantics and word meaning. Consistent with these models, certain words in a bilingual speaker's lexicon are categorized according to morphology, yet words that share meaning but not morphology (e.g. dog and *perro*), are stored separately (Kirsner et al., 1993; Van Heuven et al., 1998). Since the lexicon has words from both languages, lexical access is not language selective. Similarly, Dijkstra and his colleagues base their *Bilingual Interactive Activation (BIA)* model on an integrated lexicon, containing words from both languages. Therefore, the authors argue that both (or all) languages are active during lexical access, even when only one language is required by specific task demands (Dijkstra & van Heuven, 1998; Dijkstra & van Hell, 2003; Goral, Levy, Obler, & Cohen, 2006).

On the other hand, various other models suggest that languages have separate lexicons with a shared conceptual store, differing only in the way words are accessed. For instance, the *Word Association Model* purports that only the dominant language (L1) has access to a conceptual store via a conceptual link, and therefore words in the less proficient language (L2) are accessed via L1 (Potter et al., 1984). This model is supported by a study that analyzed the responses of bilingual speakers who were not as proficient in their L2 as they were in L1 during translation tasks. The authors found that proficient speakers of a nonnative language could independently process words in the two languages to access their underlying meanings, whereas less proficient speakers tended to use either L1 words or pictorial representations to process L2 words (Chen & Leung, 1989). A later proposal, known as the *Concept Mediation Model,* permits each lexicon direct access to the conceptual store, which better accounts for the performance of bilingual speakers proficient in both languages on picture naming tasks and translation tasks (Caramazza & Brones, 1980; Dufour & Kroll, 1995; Potter et al., 1984; Lorenzen & Murray, 2008).

Two final models, however, factor in links between the two lexicons of each language, permitting each language a link to the conceptual store, as well (Kroll & Stewart, 1994; de Groot, 1992). The *Revised Hierarchical Model* (RHM) accommodates different types and levels of bilingualism, and has received empirical support from neuroimaging studies (Hernandez, Dapretto, Mazziotta, & Bookheimer, 2001) and studies using naming and semantic tasks (Hermans, Bongaerts, De Bot, & Schreuder, 1998; Dufour & Kroll, 1995; Kiran & Edmonds, 2004; Lorenzen & Murray, 2008). Kroll and Steward (1994) incorporated both the *Word Association Model* and the *Concept Mediation Model* into a general model of bilingual memory organization. Essentially, the RHM assumes separate but interconnected lexical representations of an individual's first and second language, highlighting the bidirectional, yet asymmetric relationship between the two lexicons (Goral et al., 2006).

Similar to the RHM, de Groot's (1992) *Mixed Model* proposes connections that can vary in strength depending on the proficiency of languages, allowing for a range of language proficiencies. This includes bilingual individuals proficient in both L1 and L2, for whom connections between the conceptual system and both lexicons and between each lexicon are equally strong. Therefore, treatment in one language should result in generalization within the trained language, as well as to the untrained language (Edmonds & Kiran, 2006).

1.2 Speech-language interventions in bilingual speakers with aphasia

Comparisons across the existing literature are challenging due to discrepancies in data collection, types of participants, and remediation of a limited set of linguistic abilities using different types of treatment and outcome measures. While there is some degree of consistency in findings, many factors must still be considered when evaluating evidence-based intervention methods. For instance, although many of the studies targeted similar linguistic abilities, such as lexical retrieval or syntax, they differ in the nature of treatment approaches and treatment targets, often failing to mention type of activities included in treatment, or specific details about the protocol implemented (Faroqi-Shah, Frymark, Mullen, & Wang, 2010). Most importantly, there are many patient-related variables to consider, including pre-and post-morbid language proficiency, type of aphasia, severity of linguistic impairment in each language, as well as lesion size and location (Lorenzen & Murray, 2008). Because habitual functioning for bilingual individuals usually involves use of two or more languages, effective treatment for bilingual and multilingual individuals with aphasia should be aimed at improving abilities in all of their languages.

Various studies have considered the potential for preserved connections between an individual's two or more languages and whether the cross-linguistic generalization of treatment gains from one language to another may be possible. The current literature has focused on interventions centered on semantic-based approaches, which sought to use shared conceptual knowledge across languages (Kiran & Edmonds, 2004; Edmonds & Kiran, 2006; Kiran & Roberts, 2010); other studies included cognate-related tasks in an attempt to engage phonological similarities across languages to maximize treatment efficiency (Kohnert, 2004).

Cognates, or translation equivalent words that are etymologically similar in form and meaning, such as *elephant* in English and *elefante* in Spanish, have been extensively studied in bilingual speakers (Kohnert, 2004; Lalor & Kirsner, 2001; Roberts & Deslauriers, 1999; Costa, Santesteban, & Caño, 2005). There are consistent findings with neurologically intact adult bilinguals who have shown faster or more accurate responses to cognates relative to non-cognates (Costa, Caramazza, Sebastian-Galles, 2000). This cross-linguistic relationship between word forms holds true in bilingual aphasia treatment, as well, in different tasks, such as word reading (Langanaro & Overton Venet, 2001), and lexical decision tasks (Kohnert, 2004; Dijkstra, Grainger, & Van Heuven, 1999).

Positive findings for cross-linguistic generalization have been documented when the stronger language is targeted during treatment. For instance, in a single-subject study, researchers assessed the impact of a lexically-based treatment that trained cognates and non-cognates separately with a bilingual Spanish-English speaker with severe non-fluent aphasia (Kohnert, 2004). Prior to the stroke, the participant was reportedly very proficient in both languages, but post-morbid recovery favored his L1 (Spanish). The results indicated generalization from trained to untrained targets for both word types. However, the generalization of gains maintained and transferred from Spanish to English was evident only for cognate stimuli. Therefore, the participant showed improvement after receiving therapy in both languages. Nevertheless, generalization was only observed when therapy was administered in the language with higher post-morbid proficiency.

While results are varied, studies have also indicated that treating individuals with bilingual aphasia in their less proficient language yields positive results in their dominant language, and generalization occurs specifically when processes or representations common to both languages are targeted (Langanaro & Overton Venet, 2001; Kiran & Edmonds, 2004, Kiran & Roberts, 2010, Lalor & Kirsner, 2001; Kohnert, 2004). In a semantic naming treatment study, Edmonds and Kiran (2006) reported mixed results across three bilingual Spanish-English participants. Researchers concluded that training bilingual individuals in their pre-morbidly stronger language may result in marginal or no improvements to the weaker language, but training the weaker language may improve the stronger language. Therefore, targeting treatment on a conceptual level resulted in a beneficial influence on the stronger language. Unfortunately, the generalization of gains from a treated to an untreated language is not universal across studies of individuals with chronic aphasia. In a follow-up study, Kiran and Roberts (2010) treated four bilingual females in two different language pairs and found variable gains. Each patient responded differently to treatment in terms of their improvement on the target items, the within- and between-language generalization, and their maintenance. While all patients improved naming of trained items in the trained language, cross-language generalization to translations and semantically related items occurred only for one patient.

Goral, Rosas, Conner, Maul, & Obler (2012) reported two findings that differed from previously discussed patterns of cross-language generalization for a multilingual individual who sustained an ischemic stroke in the left middle cerebral artery. Outcomes demonstrated that 1) there were no cross-language treatment effects from a more proficient language to the less-proficient languages; and 2) there was also a lack of cross-language generalization from the least proficient language to most proficient. Nevertheless, this study did document generalization from a less proficient language to other untrained and more proficient languages. Researchers also observed better naming for cognates relative to non-cognates in the treated and untreated languages. Goral et al., (2012) also presented a different point of view of the impact linguistic and environmental factors have on cross-linguistic transfer. The authors proposed that effects of treatment might depend on the relative pre- and post-morbid language proficiency, linguistic overlap between languages, and the dominant languages in the environment at the time of treatment. Both phases of treatment were administered when the participant was in an environment where he was not exposed to his L1. As a result, Goral and colleagues presumed that the L1 might have been less active and more inhibited than the language of the environment, explaining the limited changes noted in L1 following treatment. From a clinical perspective, these outcomes offer some insight into the factors affecting bilingual and multilingual aphasia rehabilitation by reiterating the variability in patients' ability to transfer and generalize targeted items.

1.3 MONOLINGUAL TREATMENTS FOR NON-FLUENT APHASIA AND THEIR LIMITATIONS

Fluent speech production is often a focus of speech and language therapy in individuals with non-fluent or agrammatic aphasia due to the hallmark characteristics of this type of aphasia: halting, non-fluent language production, often with comorbid disordered speech symptoms consistent with apraxia of speech (AOS) and/or dysarthria (Brookshire, 2007). Few approaches exist which aim to facilitate fluent speech in nonfluent aphasia patients, and a number of these approaches have utilized singing or manipulation of prosody.

One of the earlier and more prominent approaches is Melodic Intonation Therapy (MIT). MIT was one of the first systematic aphasia treatment programs that capitalized on the preservation of prosodic abilities in patients with aphasia. The utility of singing to facilitate speech production has been documented with speech-disordered clients in the literature, and results suggest that choral singing, or singing in unison with an auditory model, may be more effective than choral speech, specifically for increasing word intelligibility, speech rate, and fluency (Cohen, 1992; Racette, Bard, & Peretz, 2006;

Yamaguchi, Akanuma, Hatayama, Otera, & Meguro, 2011; van der Meulen, van de Sandt-Koenderman, & Ribbers, 2012). Although MIT and other choral singing methods appear to be an effective means of intervention, these approaches ultimately lack in achieving naturalness at the conversational level and also require an intensive time commitment (Schlaug et al., 2010).

Alternatively, script training is a more practical approach that also capitalizes on choral speech. In script training, dialogues or monologues are learned verbatim. Often, the clinician and the client will construct a monologue or dialogue that is practiced intensively so that the client can communicate about a topic of interest to them (Goldberg, Haley, & Jacks, 2012). Participants typically progress through scripted sentences following a hierarchy of repetition, choral reading, and independent production. Research has shown that script training is an effective tool for training the production of targeted material, resulting in an increase in accurate production of words from the target script, improved grammatical output, and increased speaking rate (Youmans, Holland, Munoz, & Bourgeois, 2005; Cherney, Halper, Holland, & Cole, 2008; Lee, Kaye, & Cherney, 2009; Youmans, Youmans & Hancock, 2011; Cherney, Halper, & Kaye, 2011; Bilda, 2011).

Repetitive practice must occur regularly in order for scripts to become automatic, and the structure of this treatment makes it ideal for independent practice. As a result, script training successfully evolved to include computer software or technology to supplement one-on-one instruction with an SLP via an animated therapist, short videos of people acting out scripts, or using videoconferencing (Cherney et al., 2008; Bilda, 2011;

Cherney et al., 2011; Goldberg et al., 2012). Cherney et al. (2008) found results with their computer-animated avatar similar to those obtained through in-person instruction with a speech language pathologist. Bilda (2011) observed significant improvement in target phrase production after 10 days of using a computer-based script-training program. Computer-based script training also has the potential to increase session frequency and independent practice. Such factors may otherwise be constrained by personal, client-related factors, such as transportation, financial issues, or other events that may inhibit a client's ability to attend treatment sessions at the required frequency (Goldberg et al., 2012).

An additional study further developed computer-based script training to include audio-visual input using a technique called "speech entrainment" (Fridriksson, Hubbard, Hudspeth, Holland, Bonilha, Fromm, & Rorden, 2012). The homework-based treatment required participants with non-fluent stroke-induced aphasia to speak in unison with general (non-personalized) scripts, trained and untrained, recorded by a healthy speaker whose mouth could be seen on an iPod screen. Although the study considered three different speech production conditions, no improvements were perceived in an audio-only or spontaneous speech (without video model) condition. In comparison, an audio and visual feedback condition resulted in improved speech production, as measured by a greater variety of words and a speech rate more closely approximating normal.

Fridriksson and colleagues conducted a follow-up study that addressed the neural bases for improved speech production via speech entrainment. The authors proposed that speech entrainment may enable language processing of auditory-visual targets via a neural route that bypasses impaired motor programs in the inferior frontal gyrus (Fridriksson, Basilakos, Hickok, Bonilha, & Rorden, 2015). While speech entrainment was beneficial for patients with milder forms of apraxia of speech, severe apraxia of speech (AOS) was noted as a contraindication for this treatment. The authors postulated that, in order for speech entrainment to be suitable and beneficial to participants, motor speech planning must be largely preserved. A lesion overlap map for all participants in the study revealed that participants that benefited from speech entrainment had damage to the inferior frontal gyrus, pars opercularis and pars triangularis. Participants with damage to other regions of the left hemisphere did not benefit from speech entrainment.

A limitation of the original speech entrainment approach (Fridriksson's et al., 2012) was the general, non-personalized content of the scripts (e.g. 'how to make scrambled eggs'), which was used in order to maintain stimulus uniformity across participants. Due to the repetitive and concentrated nature of the daily homework, incentive to practice scripts is a central aspect of this treatment. Therefore, it is essential that the content of scripts, which can be developed collaboratively with family members and the clinician, is personally relevant and functional for the participant (Goldberg et al., 2012).

A second variable not considered by Fridriksson et al. (2012) and other script-based studies with non-fluent participants with aphasia is speech rate. However, a study that employed singing therapy in individuals with Broca's aphasia found a positive effect for modifying the rate of production on treatment outcomes (Racette et al., 2006). The inclusion of a tailored speech rate was hypothesized to facilitate fluency, as the slower speech rate during singing gave those with concomitant dysarthria more time to plan their speech movements.

1.4 Bilingual treatment for non-fluent aphasia

Currently, only one unpublished study has examined the effects of script training in a bilingual (Spanish-dominant) participant (Caruso & Beideman Szabo, 2014). In this study, the participant, a 50-year-old with Broca's aphasia, was trained in English on three scripts, and in Spanish on one script due to the participant's stronger verbal expression in English. A 3:1 ratio of English to Spanish scripts was chosen because the participants' social network at the time of treatment included mostly people who spoke English. As a result, it was more functional for him to work on English scripts. The content of the Spanish script was geared to reconnecting with a network of Spanish speaking friends that had faded after his stroke.

The treatment hierarchy was as follows: choral reading, repetition, oral reading, and an independent production of the script. The treatment consisted of 79 total sessions, occurring twice weekly for 50 minutes, and 1 hour a day of home practice with an iPad. The practice could be dispersed throughout the day. Home practice was facilitated by an application (Pictello) on the iPad, which created a digital storybook for each script. Pictello allowed the scripted lines to be paired with audio and a picture/video. If the participated tapped on the screen, a recording of the participant reciting the line was available to give an auditory cue. The program also allowed for use of video recordings to provide visual cues, but this option was not used for the participant. Scripts were trained to mastery, and the number of sessions to achieve mastery varied across scripts.

In this study, two of the three pre-treatment and post-treatment video recordings were randomly selected for analysis. The author's primary outcome measures were content, or percent words correct and percent words omitted, and efficiency, or words per minute (WPM). The findings demonstrated an increase in percentage of words correct from pre-treatment to post-treatment, an increase in WPM, and a decrease in words omitted. However, these results were not analyzed formally using statistics.

1.5 CURRENT STUDY

Script training has proven to be an efficacious intervention for monolingual speakers, as seen in previous studies, but published research has not been extended to examine these treatment techniques in bilingual individuals with non-fluent aphasia. The aim of the present study was to examine the effect of video implemented script training in aphasia (VISTA) on speech production/fluency and grammaticality in a Spanish-English bilingual individual with non-fluent aphasia.

A single-subject multiple-baseline design was utilized to examine the effects of the treatment, whereby eight trained scripts and two untrained scripts were assigned to a language of treatment. The current study modified previous script-training approaches by tailoring the speech rate and content of scripts to ensure that the scripted material was attainable and natural, yet challenging for the participant.

It was hypothesized that, following treatment, the participant would a) exhibit an increase in the number of correct and intelligible scripted words, b) show increased grammaticality for scripted material within languages, and c) display a greater degree of cross-linguistic generalization from Spanish to English for scripted material. This pattern of generalization was predicted based on self-reported greater ease of production in Spanish post-stroke. Further, given that previous studies demonstrated cognates have facilitated cross-linguistic generalization, a cognate dense script was included in each language with the hypothesis that these scripts would facilitate a greater degree of bidirectional generalization. Other secondary variables of interest were overall intelligibility, the number of grammatical errors and interjections, and speech rate (WPM).

II. METHODS

2.1 PARTICIPANT: RC

One individual (RC) with non-fluent, stroke-induced aphasia participated in this study (Table 1). RC was a 66 year-old right-handed woman who suffered an aneurysm in her left middle cerebral artery and subsequent cerebrovascular accident during a left lateral frontal craniotomy. Her native language was Spanish (L1) and second language was English (L2). At the time of this study, RC was one year and one month post-stroke. Following speech and language services in English, RC sought a full evaluation and treatment in Spanish, as English was reported to be significantly less accessible in terms of expressive language, relative to Spanish.

Table 1
Demographic Data for Participant

Demographic	
Age	66
Education	18 years
Handedness	Right-handed
Time Post Onset	One year; one month
Gender	Female

At the time of the initial evaluation at the University of Texas at Austin, RC presented with apraxia of speech and dysarthria. In addition to speech production difficulties, RC reported difficulties with reading, writing, and math, which were previously enjoyable activities. Her conversational speech was halting, with frequent pauses for word retrieval and articulatory placement. She spoke primarily in agrammatic, short phrases, which contained concrete words (e.g. nouns and high frequency Spanish verbs) and filler words (e.g *um, este*), as well as interjections (e.g., how do you say?;

cómo se dice?). Results of formal testing revealed significant deficits in syntax, naming, and fluency, and less pronounced deficits in cognition were also noted (Table 4).

2.1.1 Language Background

RC was interviewed and asked to complete a language-use questionnaire (Kiran, Peña, Bedore & Sheng, 2010; Tables 2 and 3). Because of the limitations of self-report, two of RC's caregivers (her husband and son) familiar with her language acquisition and use were also interviewed to corroborate information provided by the participant. Questions focused on the manner and time of acquisition for both languages, with an emphasis on use and proficiency immediately prior to the cerebrovascular accident. In general, RC tended to either overestimate or underestimate her performance across modalities.

RC was an early sequential bilingual who was exposed to Spanish from birth, and began learning English at the age of six. She lived in Mexico until the age of 40. She was reportedly very proficient in both languages pre-morbidly, and presented with a Spanish-influenced accent when speaking English. Her pre-morbid proficiency is also supported by her professional and linguistic history. Post-morbidly, RC reported that suppressing Spanish was taxing for her and for that reason English was used with less frequency. Caregiver and patient report indicated that comprehension of English was not impaired.

Table 2

Language Profile for Participant
Self and Family Perceived Ability in Each Language and Domain

Criteria	Spanish	English
Age of Acquisition (yrs)	From birth	6
Post-Stroke Proficiency[1] (%):		
Reading & Comprehension	99 [25]*	93 [20]*
Writing/Spelling	1 [5]*	2 [5]*
Speaking in Full Sentences	1 [20]	14 [15]
Relating an event	3 [15]	44 [20]
Listening/Understanding	99 [95]	48 [95]
Word-finding	2 [15]	19 [15]
Pre-morbid Daily Usage[2] (%)		
Weekday	44	56
Weekend	87	13
Six months prior to stroke[2] (%)	50	50
Post Stroke Daily Usage[2] (%)		
Weekday	82	18
Weekend	80	20

[1] Caregiver assessment (son) indicated in brackets. Responses rounded to nearest whole number.
[2] Information obtained from participant with agreement from caregivers.
**Disagreement in percentage between participant's primary and secondary caregiver. Participant's husband felt Reading/Comprehension and Writing/Spelling performance in Spanish was 20% for both, and 15% for both in English.*
Note: Percentages out of 100%.

2.1.2. Education and Work History

Prior to her stroke, RC attended the Monterrey Institute of Technology and Higher Education in Monterrey, Mexico, and earned a Master's of Business Administration degree, as well as a Bachelor's degree in accounting. RC immigrated to the United States from Mexico when she was 40 years old and has resided in Texas for the past 26 years. She also spent approximately 1 month per year in the U.S. beginning in her 20s to visit family members. She worked as a certified public accountant (CPA), a professional legal translator, an accounting professor at the Monterrey Institute of Technology and Higher Education, and as a lecturer at the University of Texas at Austin. During this time, English was the language used in her professional and social settings; both Spanish and English were used at home with her husband, children, and friends.

Table 3

Language Exposure for Primary Languages for Participant

Criteria	**Only Spanish**	**Primarily Spanish**	**Both**	**Primarily English**	**Only English**
Lifetime Exposure (%):					
Hearing	37	27	18	9	9
Speaking	30	30	20	10	10
Reading	30	30	20	10	10

2.1.3 Pre-and Post-treatment Assessments

RC was evaluated with comprehensive measures of speech, language, and cognition (Table 4). At the time of her initial evaluation at the University of Texas at Austin, RC presented with a moderate anomic aphasia, as measured by performance on the *Western Aphasia Battery-Revised* (*WAB-R*; Kertesz, 1982) and a translated Spanish version of the *WAB- Revised (*Aphasia Bank: Informal Spanish Translation, 2014; Table 4: Aphasia Quotient (*AQ*)= 67.2 (Spanish); 71.7 (English)). Her spontaneous speech was often telegraphic and halting, and she demonstrated evidence of moderate motor speech impairment. Specifically, her performance on the Motor Speech Exam (Wertz, LaPointe & Rosenbek, 1984) was consistent with moderate deficits for both apraxia and dysarthria (4 and 3 respectively, out of 8 on a severity rating scale with 0 indicating no impairment and 8 indicating no discernable response; Table 4). She showed reduced speed and accuracy of word repetition, particularly as length of stimuli increased.

RC demonstrated a moderate impairment in syntax comprehension on the Bilingual Aphasia Syntactic Comprehension subtest (Paradis & Libben, 1987) with more errors on passive sentences with subject/object word order variation ("it's the truck that pulls the car"), as well as similar passive negative sentences ("The truck is not pulled by the car"). A nonverbal syntax production impairment was observed in English on a shortened version of the *Northwestern Anagram Test (NAT;* Thompson, 2011) with fairly accurate performance on canonical structures and severe impairment on non-canonical structures (4/12 total sentences or questions).

Confrontation naming on the *Boston Naming Test* (*BNT*: Kaplan, Goodglass & Weintraub, 2001; Kaplan, Goodglass, & Weintraub, 1986) was impaired in both languages (17/60 items in Spanish and 19/60 items in English). RC's semantic knowledge was preserved, as measured by the picture version of the *Pyramids and Palm Trees Test* (100%*) (PPT*; Howard & Patterson, 1992; Breining, Lala, Martínez Cuitiño, Manes, Peristeri, Tsapkini, & Hillis, 2015).

Assessment of reading and spelling was conducted in English. RC demonstrated a mild impairment for single word reading and a more severe impairment for pseudoword reading (27/36 correct for words; 6/18 for pseudowords), and spelling performance was severely impaired for real words and pseudowords (7/20 for words; 4/10 for pseudowords). Example errors for real words included "bat/battle" for "bowl" (an irregular high-frequency word) and "zokiht" for "succinct" (an irregular low-frequency word).

Table 4.
Selected Speech, Language, and Cognitive Test Performance Pre- and Post-Treatment for RC

Assessment	Pre-Tx (Spn)	Pre-Tx (Eng)	Post-Tx (Spn)	Post-Tx (Eng)	3.5 mth FU (Span)	3.5 mth FU (Eng)	Normative Data (Mean)
Mini Mental State Exam (30)	18	20	27	23	---	---	S: 29.0 (1.3)[1] E: 29 (1)[2]
Stroop task (77)							NA
Stroop Color naming (# correct/ 1 minute)	7	6	13	7	---	---	
Color naming (uncorrected errors)	1	1	1	0	---	---	
Interference (# correct/1 minute)	2	0	11	6	---	---	
Interference (uncorrected errors)	2	3	0	1	---	---	
Western Aphasia Battery aphasia quotient (100)	67.2	71.7	75.7	72.9	71.7	69.4	S: Unknown E: 93.8 (4.7)[3]
Spontaneous Speech (20)	13	13	13	14	---	---	
Auditory Verbal Comprehension (10)	8.5	7.75	8.55	7.75	---	---	
Repetition (10)	7.5	7.3	8.4	7.8	---	---	
Naming and Word Finding (10)	4.6	7.8	7.9	6.9	---	---	
Boston Naming Test (60)	17	19	37	25	41	22	S: 53.3 (3.1)[4] E: 54.9 (4.3)[5]
Pyramids and Palm Trees: pictures (14)	---	14	---	---	---	---	E: 13.9 (0.24)[6]
Motor Speech Evaluation-apraxia rating (0-7)	4	4	---	---	---	---	NA

[1] MMSE Norms for ages 50–65 years (Peña-Casanova, Blesa, Aguilar, Gramunt-Fombuena, Gómez-Ansón, Oliva, & Martínez-Parra, 2009).
[2] *MMSE* Norms for ages 50-54 (Crum, Anthony, Bassett, and Folstein, 1993).
[3] WAB norms for mixed group of nonbrain and nondominant hemisphere controls (Kertesz & Poole, 1974)
[4] BNT Normative Data for University educated female women over 60 yrs (Rami, Serradell, Bosch, Caprile, Sekler, Villar, Canal & Molinuevo, 2008)
[5] BNT Normative Data for females ages 25-88 (Tombaugh and Hubley, 1997).
[6] PPT Normative Data for ages 43-80 (Breining, Lala, Martínez Cuitiño, Manes, Peristeri, Tsapkini, & Hillis, 2015).
FU=Follow up

Table 4. Continued

Selected Speech, Language, and Cognitive Test Performance Pre- and Post-Treatment for RC

Motor Speech Evaluation-dysarthria rating (0-7)	3	3	---	---	---	---	NA
Northwestern Anagram Test (UT-short)							NA
Active Sentences (2)	---	1	---	2	---	---	
Passive Sentences (2)	---	1	---	2	---	---	
Subject Wh-Questions (2)	---	1	---	2	---	---	
Object Wh-Questions (2)	---	0	---	0	---	---	
Subject Relatives (2)	---	1	---	2	---	---	
Object Relatives (2)	---	0	---	0	---	---	
Bilingual Aphasia Test							Unknown
Syntactic Comprehension (87)	58	61	64	57	---	---	
Grammaticality Judgments (10)	7	6	10	9	---	---	

2.1.4 Imaging Characteristics

RC incurred an aneurysm in her left middle cerebral artery and subsequently had a second cerebrovascular accident during a left lateral frontal craniotomy. Following these events (11 months prior to receiving treatment in this study), a clinical MRI was conducted. RC's magnetic resonance imaging (MRI) scans revealed extensive damage to the left frontal, and left anterior temporal lobes (Figures 1 and 2). This lesion profile is consistent with RC's prominent anomia, telegraphic speech, and reported difficulty with language suppression.

Figure 1. Clinical MRI scan showing prominent lesion in the left anterior temporal lobe (see arrow).

Figure 2. Clinical MRI scan showing subdural hematoma in the left frontal lobe (see arrow).

2.2 Script Development

Ten total scripts were developed for RC via a collaborative process involving the participant, family members, and the clinicians. The participant selected five topics in each language, and four per language were randomly selected to enter treatment; of those four, one script contained a high proportion of cognates. These scripts contained 16/34 and 14/38 cognates out of total words in the scripts, as compared to other scripts, whose cognate count varied from 0-5 (mean=2.75). Two additional scripts served as untrained, within-subject controls (see Appendix).

RC selected script topics (e.g. about me, family, career, etc.) and generated sentences, which were then modified by the clinician in order to balance trained and untrained scripts for number of words, number of sentences, complexity, and readability (see Appendix). Ease of readability was assessed using a Flesch Kincaid reading score (Flesch, 1948) and a free online program, which calculated scores for each script (Online Readability Calculator, n.d.; https://readability-score.com/.). Scripts were limited to approximately four sentences. Each script followed a similar format (e.g., three statements and a question). Clinicians sought to avoid sentences that started the same way and sentences that listed information. In general, scripts in Spanish had a higher percentage of complex words (as measured by syllable and letter length), but due to the fact that Spanish has more simple words that are multisyllabic, the discrepancy was perceived to be negligible.

After scripts were generated, a team of undergraduate and graduate students video-recorded each script. A female mouth model that was a simultaneous Spanish-English bilingual read the client's script at the participant's approximate maximum speech rate using a metronome for pacing. A mouth model that spoke a Mexican dialect of Spanish was selected in order to avoid a dialectical mismatch with the patient. To determine the tailored rate for the audio-video stimuli, the participant's words produced per minute (WPM) were derived in each language from both a picture description speech sample and a reading passage. RC's average connected speech rate was 40 WPM, an average of the speech sample and reading passage.

2.3 Treatment

A video implemented script training treatment (VISTA) was implemented to facilitate fluent and intelligible speech through training with a visual and auditory speech model via an iPad. The VISTA protocol encompassed two components: 1) weekly 1-hour sessions with a speech-language pathology graduate clinician (the author) using a hierarchy of tasks designed to promote memorization and conversational usage of scripts (Table 5), and 2) daily homework of at least 30 minutes using video stimuli of individualized scripts on the iPad.

2.3.1. Protocol

The training hierarchy used for in-session practice moved from structured tasks (e.g. targeting accuracy and intelligibility), to more functional tasks (e.g. using scripted sentences out of order and in conversation with novel conversational partners) in order to promote memorization and generalization (Table 5). Speech sound errors were addressed through targeted articulation practice during therapy via drills and visual placement cues, as well as independently during homework.

Table 5.
Clinician-Guided VISTA Treatment Hierarchy

Participant is asked to:

1. Choose each correct script sentence from four foil sentences.
2. Put the script sentences in the correct order.
3. Read the entire script aloud.
4. Produce individual scripted sentences in response to questions.
5. Produce the entire script from memory.
6. Respond to questions with scripted sentences out of the correct order of the script
    - During the second treatment session for a given script, a novel communication partner has an unscripted conversation with the participant to promote conversational usage of scripted material.

******Note***. Feedback regarding articulation and grammar occurred during steps 3-6, with targeted practice, as needed.**

2.3.2. Homework

Daily homework occurred at the patient's place of residence using video stimuli of individualized scripts on the iPad. RC was asked to log the number of minutes of training that she completed daily and the clinician monitored training progress twice a week by reviewing homework logs with the patient. The participant was asked to practice for at least 30 minutes a day for an assigned script (one script at a time). During practice, RC attempted to mimic a speaker in real-time whose mouth was made visible on the screen of an iPad and whose speech was heard via headphones. Additionally, RC practiced a list of words identified by the clinician, which had been difficult for RC to articulate during in-session practice.

2.3.3. Training criteria

All four Spanish scripts were treated first, followed by the remaining four English scripts. Criterion for mastery was set at 90% correct and intelligible words, with a minimum of two and a maximum of three treatment sessions per script. If the participant met criterion in the second session, she moved on to a new trained script. If criterion was not met after three sessions, the participant moved on to a new trained script. Script accuracy on all scripts (trained and untrained) was probed at the beginning of each treatment session, so that all scripts were probed once per week in each language. Generalization was assessed via performance on untrained scripts, and by post-treatment performance on the *Northwestern Anagram Test* (NAT; Weintraub, Mesulam, Wieneke, Rademaker & Rogalksi, 2009), the *Boston Naming Test* administered in English and Spanish (*BNT*; Kaplan, Goodglass & Weintraub, 2001; Kaplan, Goodglass, & Weintraub, 1986), the *Western Aphasia Battery-Revised* administered in English and Spanish (*WAB-R*; Kertesz, 2006; Aphasia Bank: Informal Spanish Translation), and subtests of the *Bilingual Aphasia Test* (*BAT*; Paradis, 1987). Intelligibility was defined as whether the rater could understand the target word within the context of the script topic. Each word was coded online by the clinician as intelligible or unintelligible, and as present or omitted relative to each script.

2.3.4. Data Collection

One trained undergraduate coders, blind to the study conditions, used CHAT and CLAN (MacWhinney & Snow, 1985) to transcribe all probes and to code unintelligible words. Productions that were deemed unintelligible were transcribed phonetically. A correct production required that the word was a lexical unit from the script and that it was intelligible within the context of the script. If the participant self-corrected, the rectified response was counted as correct. Percentage of grammatical errors, overall intelligibility, words per minute (WPM), number of interjections, number of correct scripted cognates produced, and accuracy of scripted words by word class were calculated for trained and untrained scripts for two time points during pre-treatment, treatment and post-treatment sessions.

2.3.5 Statistical analysis

In order to establish treatment efficacy and to compare treatment outcomes across conditions, treatment effect sizes were calculated. To calculate the treatment effect size, performance for each script was established at three different time points: the average of two sessions during pre-treatment, two sessions during mid-treatment (when the language of intervention changed from Spanish to English), and three to four sessions during post-treatment. These values were used to calculate *d*-statistics for each script (see Beeson & Robey (2006) for how to calculate *d*).

In the area of aphasia treatment, benchmarks for *d* statistics have been established from a review of single-subject research in aphasia conducted by Robey, Schultz, Crawford, and Sinner (1999). With one extreme outlier removed from the effect sizes derived from 12 studies, the first, second, and third quartiles for the *d* statistic were 2.6, 3.9, and 5.8, corresponding to small-, medium-, and large-sized effects (Robey, Schultz, Crawford, & Sinner, 1999; Beeson & Robey, 2006).

Wilcoxon signed-rank tests were conducted to compare pre-treatment performance with post-treatment and follow-up performance on grammaticality and intelligibility measures for scripts, as well as performance in different grammatical word classes, speech rate (WPM), and cognate performance. McNemar and Cochran tests were used to compare pre- versus post-treatment and 3.5 month follow up scores on select language measures, including the *BNT* in English and Spanish (Kaplan, Goodglass and Weintraub, 2001; Kaplan, Goodglass, & Weintraub, 1986), NAT (NAT; Thompson, 2011), and the *BAT* subtests of Syntactic Comprehension and Grammaticality Judgment (*BAT*; Paradis & Libben, 1987).

III. RESULTS

3.1 Treatment Duration

RC participated in three months (approximately 13 weeks) of treatment, with sessions occurring twice weekly for one hour, for a total of 26 hours of direct contact with the clinician. RC also completed at least 30 minutes of homework seven days per week, totaling approximately 46.5 total hours of homework.

3.1.1 Primary Outcome Measure: Percent Correct and Intelligible Scripted Words

Multiple baseline data for RC's performance on spontaneous speech probes for trained and untrained scripts in both languages are shown in Figure 3 (Spanish) and Figure 4 (English). Additionally, cross-language generalization is mapped onto each figure.

On Spanish-assigned scripts, her performance was relatively stable over the first two pre-treatment probes. As treatment was implemented, RC showed improvement on trained scripts on the primary outcome measure of percent correct, intelligible words. This ascending trend in performance indicated application of self-monitoring and articulation strategies used during treatment sessions and independent homework practice. However, RC did not demonstrate mastery (90% correct, intelligible words or better) on all scripts. As shown in Figure 3, RC demonstrated mastery on two Spanish trained scripts within three sessions (e.g., Family and About me), achieved 89% on one script (e.g., Friends), and maintained good performance for the duration of the training period.

On English-assigned scripts, her performance was relatively stable over the first two pre-treatment probes, and as treatment was implemented, RC's performance showed general improvement on trained scripts on the primary outcome measure of percent correct, intelligible words from scripts (Figure 4). With the exception of one script (Career), she did not achieve mastery of English scripts within three sessions. RC did not achieve mastery of any cognate-dense script in either language, although both scripts showed improvement compared to baseline performance, as seen by the small and medium effect sizes for English and Spanish scripts respectively.

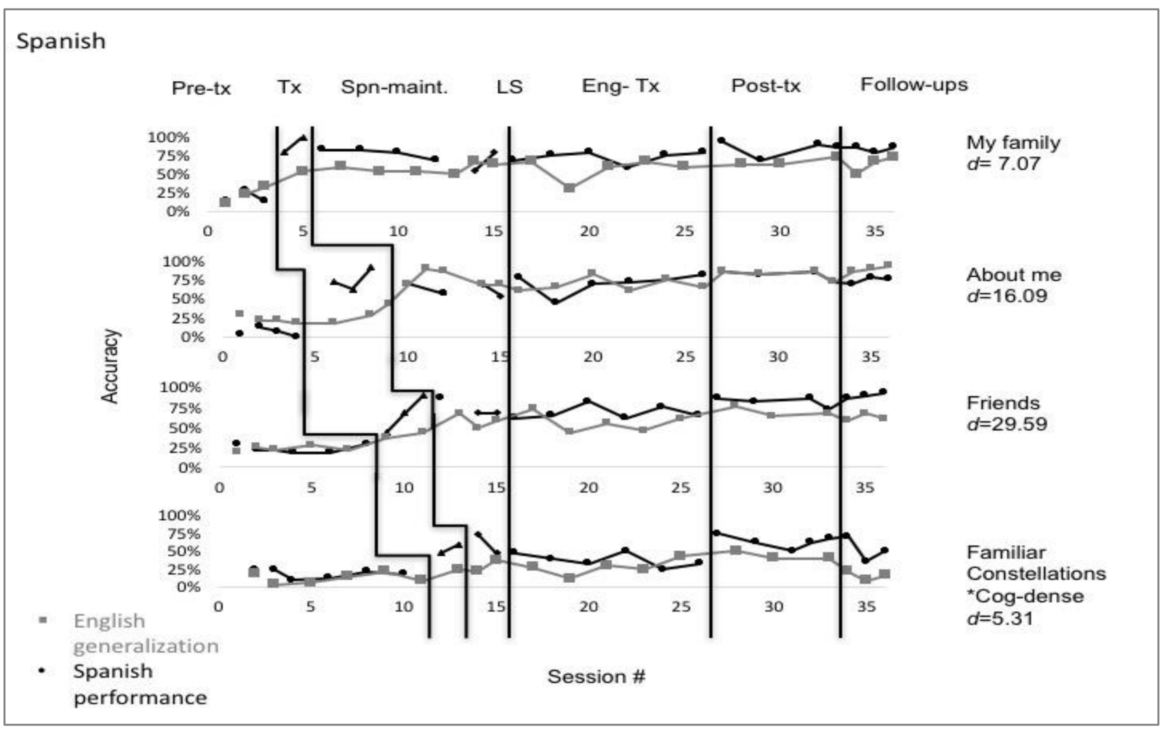

Figure 3. Multiple-baseline data for NL's performance during and after VISTA for Spanish-trained scripts. Phases of treatment are indicated by vertical lines, including baseline, treatment sessions, the language-switch for language of intervention (LS), maintenance sessions, post-treatment probes, and follow-up visits (at 1.5 and 3-months post-treatment). Spn= Spanish, Eng= English, Tx=Treatment and Maint.= Maintenance, *cog-dense= high proportion cognate script.

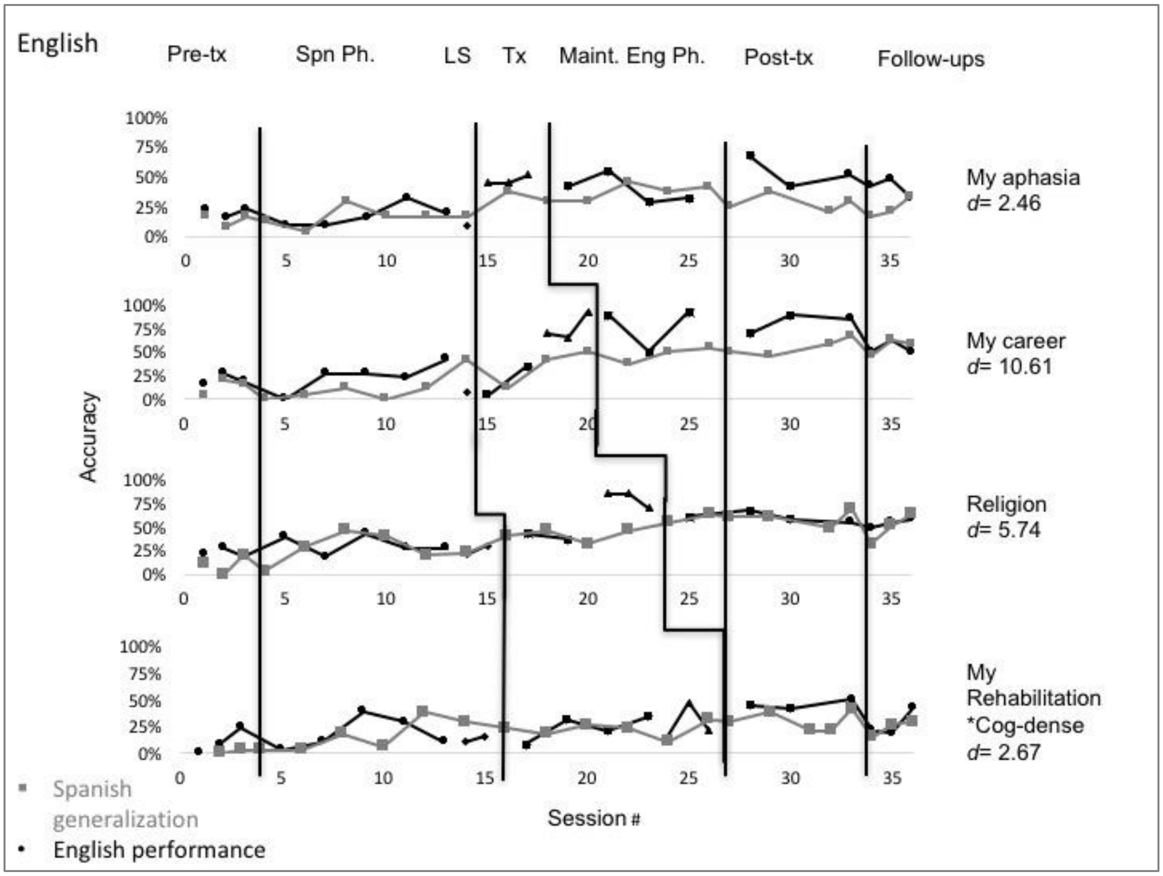

Figure 4. Multiple-baseline data for NL's performance during and after VISTA for English-trained scripts. Phases of treatment are indicated by vertical lines, including baseline, treatment sessions, the language-switch for language of intervention (LS), maintenance sessions, post-treatment probes, and follow-up visits (at 1.5 and 3-months post-treatment). Spn= Spanish, Eng= English, Tx=Treatment and Maint.= Maintenance, *cog-dense= high proportion cognate script.

Figure 5 shows stable performance on untrained scripts throughout the course of treatment, with performance of scripts and cross-language generalization below 50% mastery.

At three and a half months post-treatment, RC was able to recall three Spanish-assigned non-cognate dense scripts and one English-assigned non-cognate dense script with 60-73% accuracy. There was a slight decline in performance for cognate-dense scripts and English-assigned scripts (e.g performance under 60%).

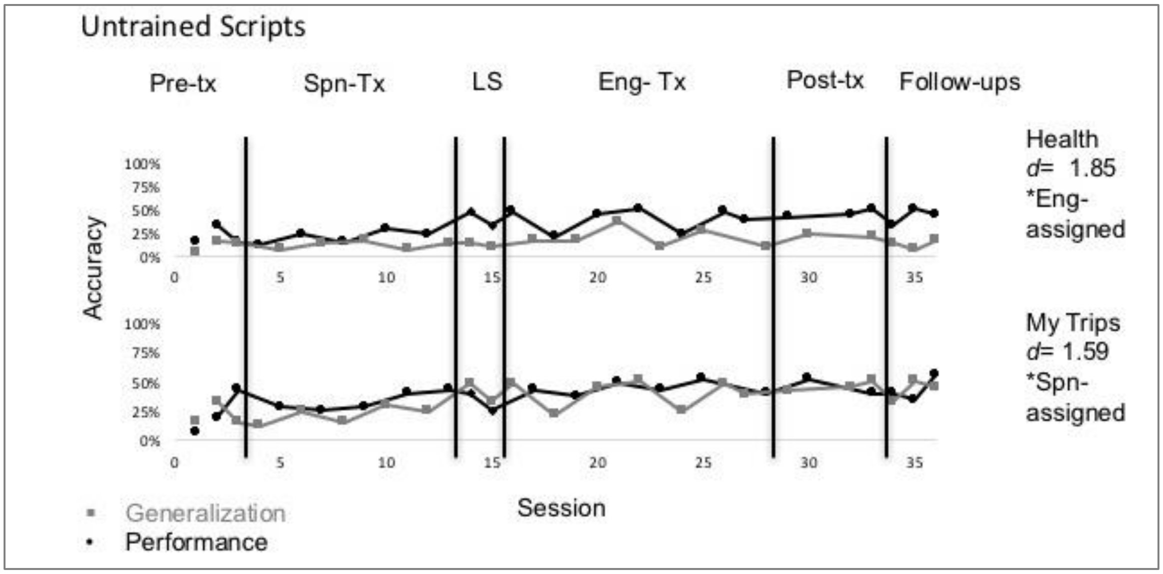

Figure 5. Multiple-baseline data for NL's performance during and after VISTA for untrained scripts. Phases of treatment are indicated by vertical lines, including baseline, treatment sessions, the language-switch for language of intervention (LS), maintenance sessions, post-treatment probes, and follow-up visits (at 1.5 and 3-months post-treatment). Spn= Spanish, Eng= English, Tx=Treatment and Maint.= Maintenance, *cog-dense= high proportion cognate script.

3.1.2 Treatment Effect Sizes

To estimate the treatment effect size, the change in the level of performance on the average of two sessions during pre-treatment, mid-treatment, and post-treatment for each trained script was compared, and *d*-statistics were calculated for each script. The weighted effect size post therapy for all Spanish-assigned trained scripts was 14.67, a robust, positive response to treatment indicated by large effect sizes (*d*>5.8) for the trained scripts from baseline to post-treatment (see Robey et al., 1999, as well as Beeson & Robey, 2006, for calculation details). The weighed effect size for Spanish untrained scripts post-treatment was 1.71, indicating minimal change for untrained topics.

The weighted effect size for all English-assigned trained scripts post-treatment was 5.07, a positive response to treatment indicated by medium effect sizes (*d*>3.9) for the trained scripts from baseline to post-treatment. The weighted effect size for English untrained scripts was 1.68, indicating minimal change for untrained topics.

A z-test was conducted to compare the effect sizes from each treatment condition. Table 6 details effect sizes by treatment phase, cognate status and cross-language generalization. Regarding performance on Spanish scripts, a z-test revealed a large positive significant difference between trained and untrained scripts from pre- to post-treatment (z= 5.02, p<0.0001), and from pre- to post-Spanish treatment (z=3.73, p<0.0001).

Regarding performance on English scripts, the z-test revealed a smaller, positive, significant difference between trained and untrained scripts from pre- to post- treatment (z= 2.65, p=0.004). A nonsignificant difference between trained and untrained scripts was observed from pre- to post-Spanish treatment (z=1.16, p=0.12) for the same scripts. However, a significant difference was not expected to emerge from pre- to post- Spanish treatment for scripts that were not treated in Spanish.

Table 6.
Effect Sizes (d statistics) for Trained Scripts by Language of Treatment, Cognate Status and Treatment Phase

Phase	**Post-Spanish Tx***	**Post-all Tx***
Spanish-trained scripts		
All trained	11.77	14.67
Trained (cognate-dense script excluded)	14.38	18.83
Cognate script	4.98	5.31
Untrained scripts	2.48	1.71
Generalization to English	6.12	16.13
Generalization to English (cognate-dense script excluded)	7.40	11.30
English-trained scripts		
All trained	-0.29	5.07
Trained (cognate-dense script excluded)	-0.31	5.83
Cognate script	-0.24	2.67
Untrained script	0.75	1.68
Generalization to Spanish	2.18	7.74
Generalization to Spanish (cognate-dense script excluded)	2.27	6.17

**Note*: Tx= treatment.

3.2 SECONDARY VARIABLES OF INTEREST

In addition to measuring percent correct intelligible words from scripts, secondary variables of interest were as follows: number of grammatical errors, speech rate, number of interjections, number of correct scripted cognates produced, accuracy of scripted words by word class, and overall intelligibility. The mid-treatment time point occurred when the language of intervention changed from Spanish to English. Thus, the mid-treatment time point is synonymous with post-Spanish intervention, and pre-English intervention. In addition to conducting language-specific analyses (e.g. Spanish-trained scripts), we conducted analyses across all trained scripts (e.g. performance in Spanish on both Spanish and English trained scripts, and performance in English on both Spanish and English trained scripts) due to limited statistical power, which may hinder the ability to detect change related to language of training and cross-linguistic generalization.

3.2.1 Frequency of Grammatical Errors

The total number of grammatical errors was calculated before, during, and after treatment for trained scripts for English and Spanish. Figure 6 shows an increase in the frequency of grammatical errors for cognate-dense scripts at the mid-treatment time point for both English and Spanish-assigned scripts produced in English. Figure 7 shows a similar pattern for both English and Spanish-assigned scripts produced in Spanish. However, Spanish-assigned trained scripts showed a consistent decline in grammatical errors when produced in English and Spanish.

For all trained scripts (both Spanish and English-assigned scripts) produced in English, a Wilcoxon signed-rank test revealed significant decrease for the total number of grammatical errors for all trained scripts (pre- to post-treatment, $z=-1.85$, $p=0.03$, one-tailed), and for Spanish-trained scripts (mid- to post-treatment, $z= -1.89$, $p=0.03$, one-tailed). Differences across time points were nonsignificant for untrained and English-trained scripts.

For all trained scripts produced in Spanish, Wilcoxon signed-rank tests revealed nonsignificant differences for the total number of grammatical errors for all trained scripts, English-trained scripts, and untrained scripts produced in Spanish across time points. However, there was a significant decrease for Spanish-trained scripts (pre to post-treatment (z= -1.84, p=0.033, one-tailed); mid- to post-treatment (z= -1.84, p=0.033, one-tailed).

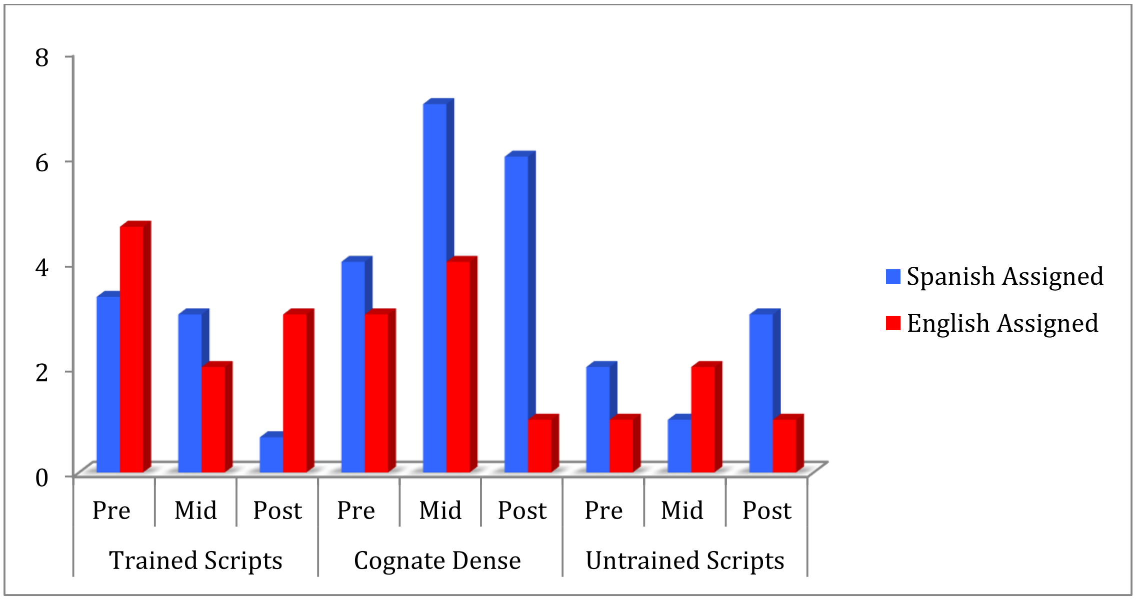

Figure 6. Frequency of Grammatical Errors for all Scripts Produced in English.

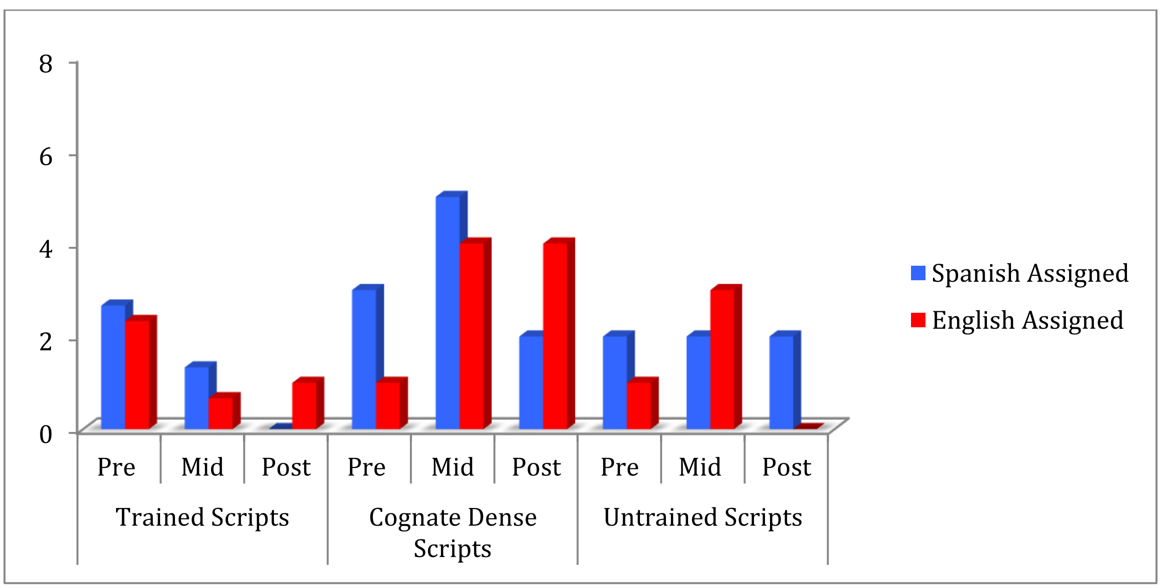

Figure 7. Frequency of Grammatical Errors for all Scripts Produced in Spanish

3.2.2 Speech Rate

Changes in the number of words per minute (WPM) were calculated from pre-treatment to mid-treatment and post-treatment for trained scripts for English and Spanish. RC's WPM did not reach higher than 35 WPM for performance on scripts produced in English or Spanish (Figures 8 and 9, respectively). Visual inspection revealed an increase in RC's WPM for most trained scripts from pre- to post- treatment. In general, RC's rate showed a small drop in her production of all trained and cognate-dense scripts, produced in English and Spanish, from mid- to post-treatment time points. RC's lowest WPM rates for either language occurred when producing cognate-dense scripts (e.g 12-25 WPM).

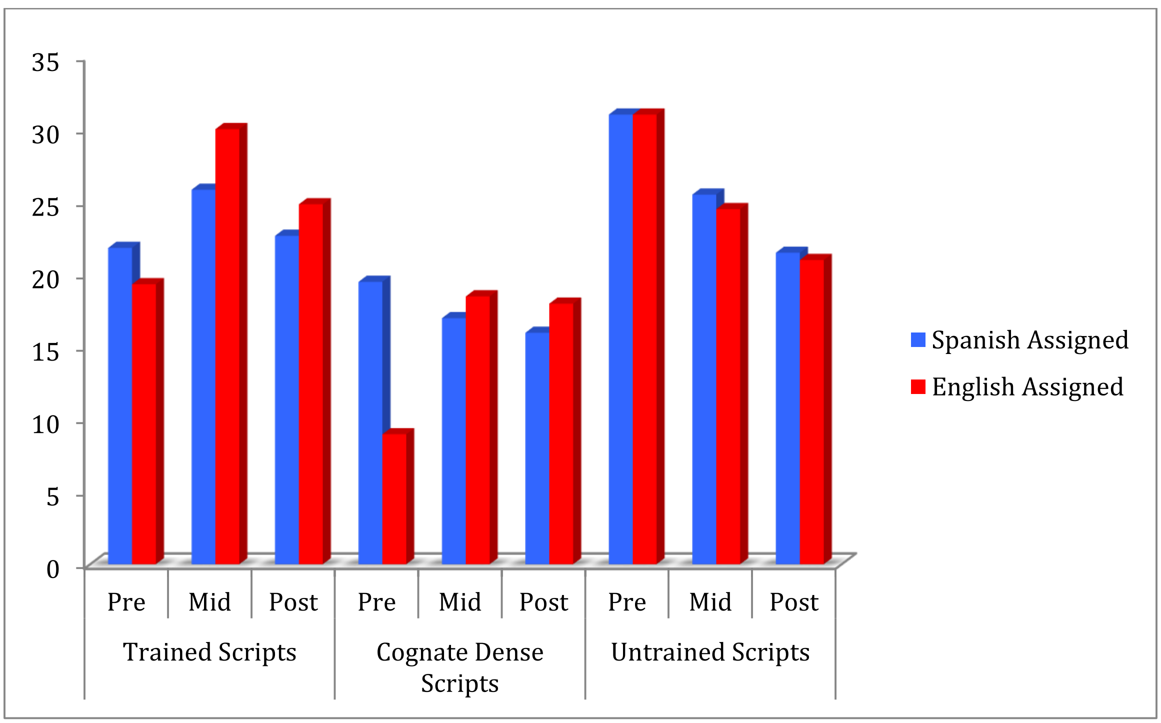

Figure 8. WPM Performance for Scripts Produced in English Across Time Points.

A Wilcoxon signed-rank test revealed significant increase in WPM for English trained scripts produced in English, (pre- to mid-treatment, z=-1.841, p= 0.033, one-tailed), for all trained scripts produced in Spanish (pre- to mid- treatment, z= -2.380, p=0.0085, one-tailed), and for Spanish performance on English trained scripts (pre- to mid-treatment, z= -1.826, p= 0.034, one-tailed). Yet, there were was also a significant decrease for all trained scripts produced in Spanish and for Spanish performance on English trained scripts from mid- to post-treatment ((z=-2.521, p= 0.006, one-tailed) and (z= -1.826, p= 0.034, one-tailed)), respectively. However, WPM differences for other analyses were non-significant.

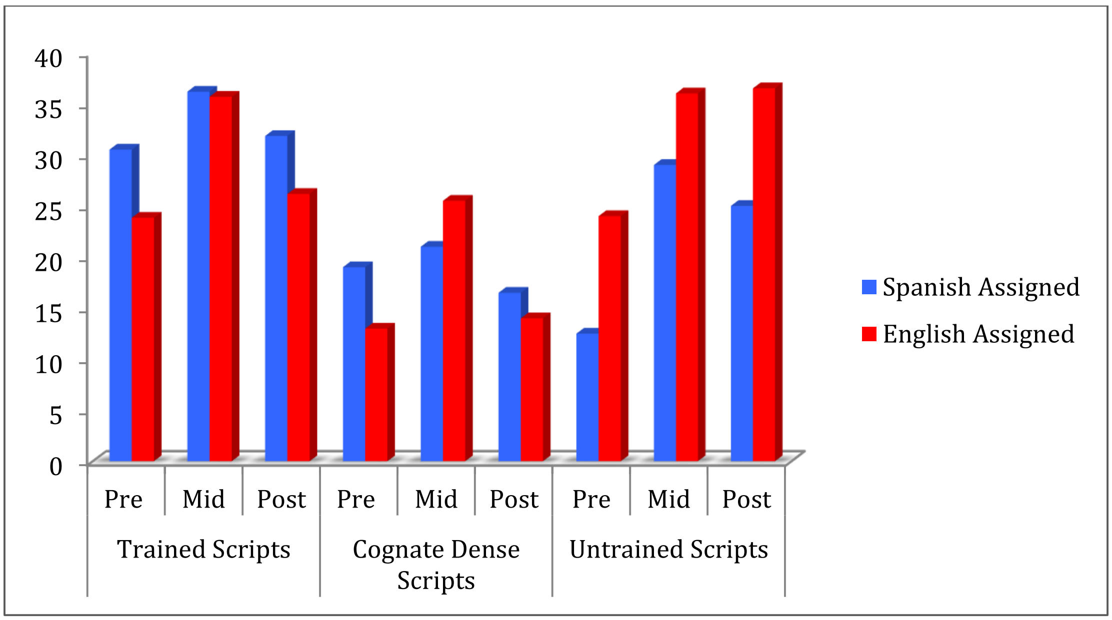

Figure 9. WPM Performance for Scripts Produced in Spanish Across Time Points.

3.2.3 Frequency of Interjections

The total number of interjections was calculated before, during, and after treatment for trained scripts produced in English and in Spanish. Figure 10 shows the frequency of interjections for all scripts produced in English. Visual inspection revealed a large decline in number of interjections for trained scripts and for cognate-dense scripts produced in English. Figure 11 shows the frequency of interjections for all scripts produced in Spanish. While Spanish-assigned scripts showed a consistent decline in interjections produced, English-assigned scripts produced in Spanish showed inconsistent patterns, with a higher number of interjections at the mid-treatment time point for trained scripts and cognate-dense scripts produced in Spanish.

Regarding all scripts produced in English, Wilcoxon signed-rank tests revealed significant decrease for the total number of interjections for 1) all trained scripts across all time points (pre- to post-treatment z= -2.366, p= 0.009, one-tailed; pre to mid-treatment z= -2.197, p= 0.014, one-tailed; mid to post-treatment z= -2.375, p= 0.009, one-tailed), for 2) English trained scripts across all time points (pre- to post-treatment z= -1.826, p=0.034, one-tailed; pre to mid-treatment z= -1.826, p= 0.034, one-tailed; mid- to post-treatment z= -1.604, p= 0.055, one-tailed); and 3) English performance on Spanish trained scripts (pre- to post- treatment, z= -1.604, p= 0.055, one-tailed.) Differences for untrained scripts produced in English were nonsignificant.

With regard to all trained scripts produced in Spanish, Wilcoxon signed-rank tests revealed a significant decrease for the total number of interjections for all trained scripts (pre-to post- treatment, z=-2.023, p= 0.022, one-tailed; mid- to post- treatment, z= -1.843, p= 0.033, one-tailed). Differences across time points for other analyses were non-significant.

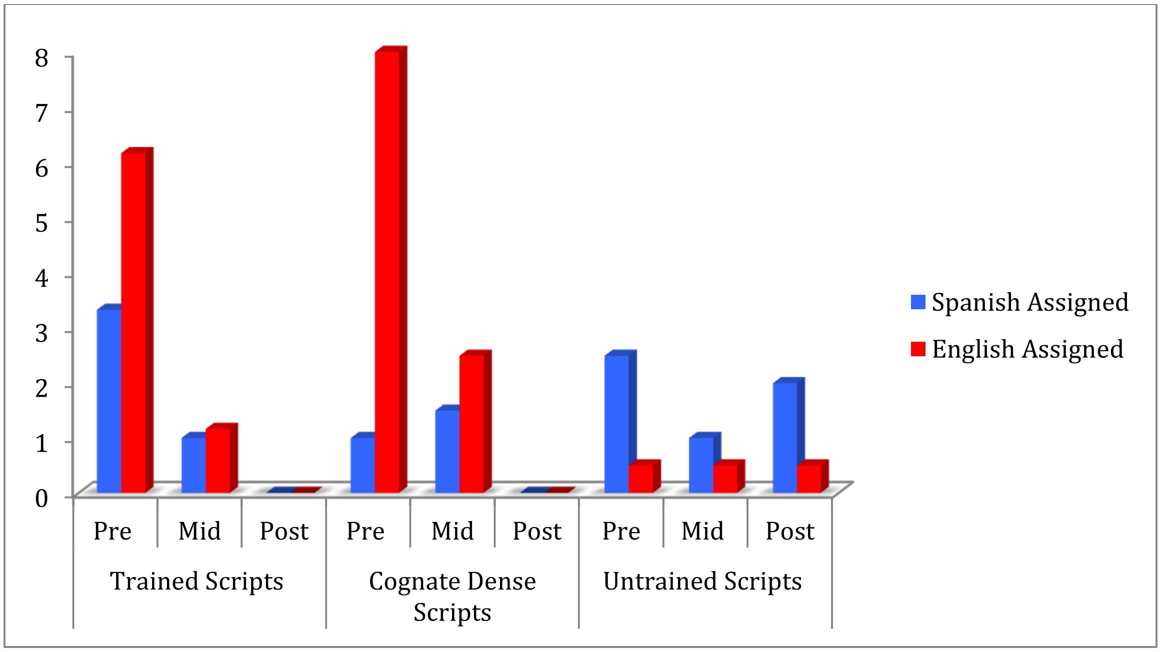

Figure 10. Frequency of Interjections for all Scripts Produced in English

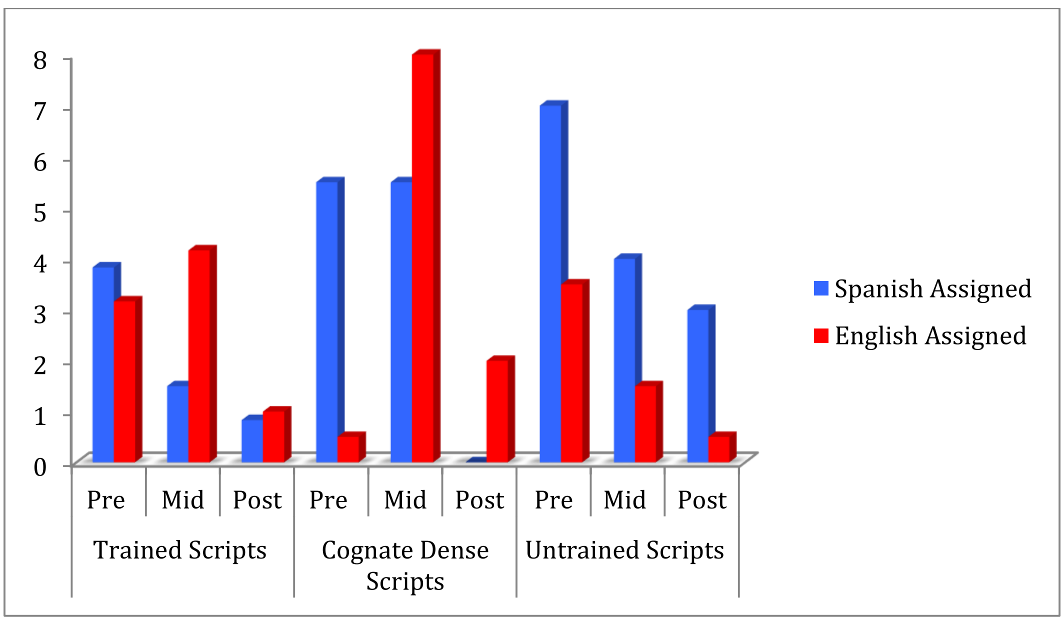

Figure 11. Frequency of Interjections for all Scripts Produced in Spanish

3.2.4 Cognate Status

The number of cognates produced out of the total number of scripted cognates was calculated before, during, and after treatment for trained scripts produced in English and Spanish. For the purposes of these analyses, we separated scripts into cognate-dense, non-cognate dense, or untrained. Non-cognate dense scripts represent the six scripts that contained a lower proportion of cognates. Visual inspection of English production demonstrated that smaller improvements were noted for English-assigned scripts relative to Spanish-assigned scripts. RC recalled a higher percentage of cognates for non-cognate dense and cognate-dense Spanish-assigned scripts (Figure 12) compared to English-assigned scripted. For scripts produced in Spanish, RC also produced a higher percentage of cognates for non-cognate dense, cognate-dense and untrained Spanish-assigned scripts (Figure 13).

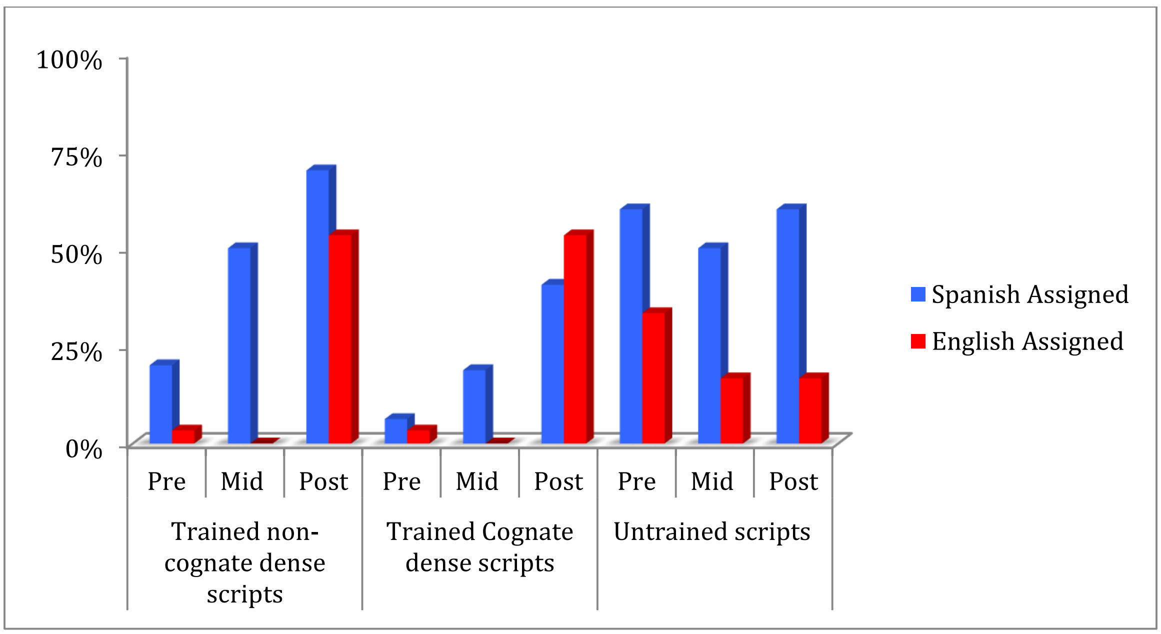

Figure 12. Percentage of Cognate Use for Scripts Produced in English.

A Wilcoxon signed-rank test revealed significant increase in the number of cognates present in all trained scripts produced in Spanish (pre- to post-treatment, z=-1.960, p=0.025, one-tailed; and mid- to post- treatment time points, z=-1.703, p=0.045, one-tailed). However, differences were nonsignificant for all remaining contrasts.

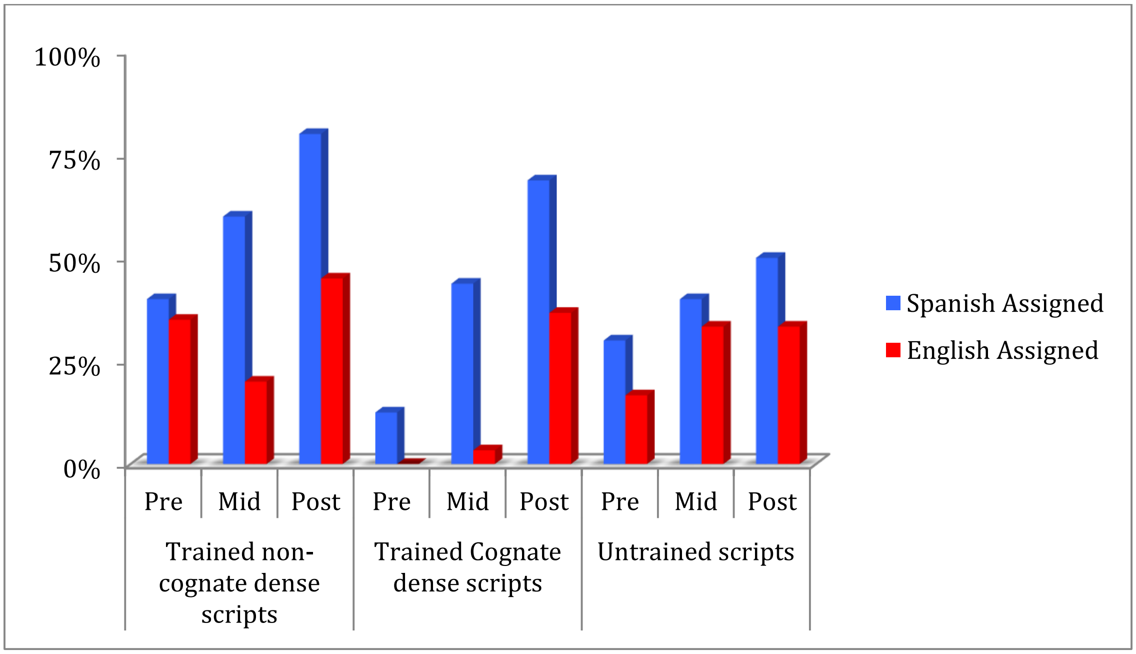

Figure 13. Percentage of Cognate Use for Scripts Produced in Spanish

3.2.5 Accuracy by Word Class

The number of words produced correctly in each grammatical class was calculated before, during, and after treatment for trained scripts for English and Spanish. Given the stability in performance in pre, mid, and post-treatment probes, one data point for each phase of treatment was selected to analyze word class percentages. Word class types not included in the figures below indicate that those word classes were not present in the scripts. For English trained scripts, RC showed improvement for all grammatical classes except for first and third person, and present participle words. Nouns, third person singular words, and functors (e.g. conjunctions, determiners, and prepositions) showed the most significant improvement (Figure 14). Grammatical class accuracy did not generalize to untrained scripts produced in English, which only revealed a modest increase in accuracy for nouns and functor words (Figure 15).

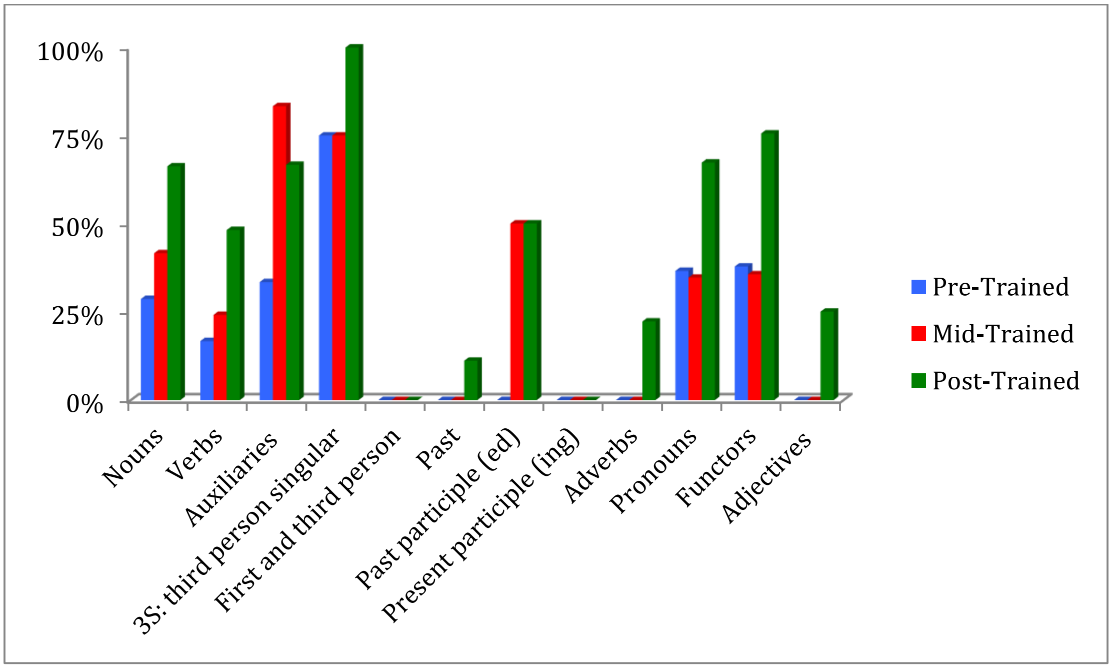

Figure 14. Percentage of Word Class Use Across English Trained Scripts

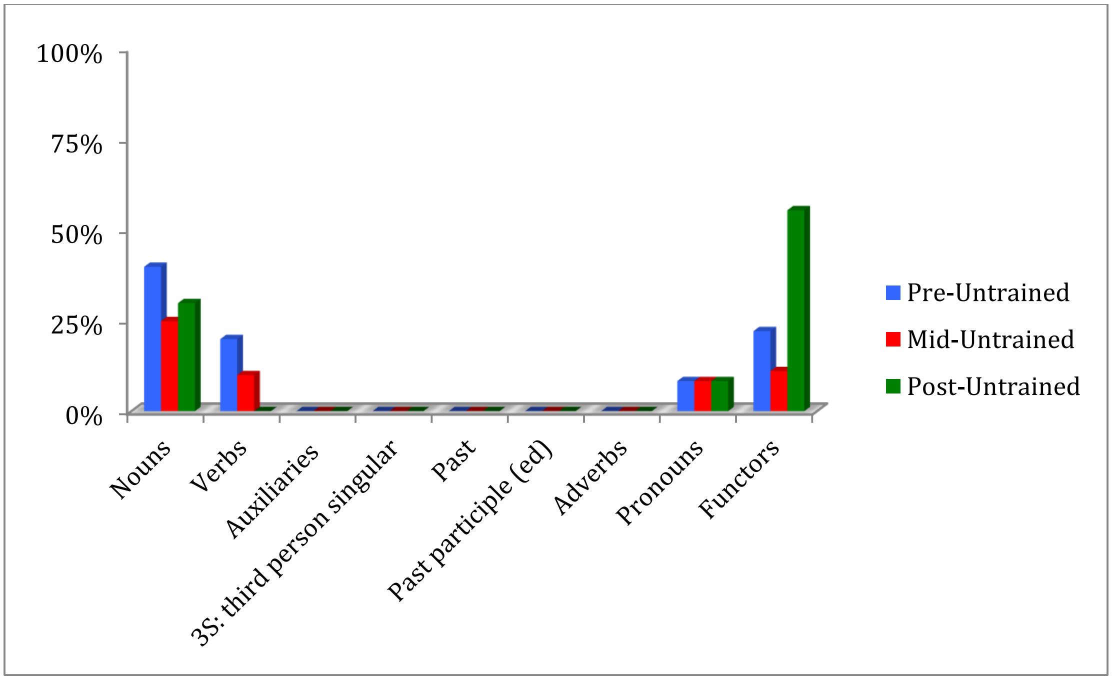

Figure 15. Percentage of Word Class Use Across English Untrained Scripts.

For Spanish trained scripts, RC showed improvement for all grammatical classes, except first and third person singular words. Nouns, auxiliaries, adverbs, pronouns, functors, and adjectives showed the most significant improvement for the Spanish trained scripts (Figure 16). Similarly, grammatical class accuracy did not generalize to Spanish untrained scripts, which revealed minimal increase from pre- and mid- to post- treatment time points in accuracy for all grammatical classes (Figure 17).

Wilcoxon signed-rank tests revealed significant increases in the number of word-class types generated following treatment for 1) all trained scripts produced in English (pre- to post-treatment, z=-3.184, p=0.0005; mid- to post-treatment, z=-2.905, p=0.002, one-tailed), and 2) all trained scripts produced in Spanish across time points (pre- to post-treatment z=-2.803, p=0.0025, one-tailed; pre- to mid-treatment z=-2.805, p=0.0025, one-tailed, mid- to post-treatment z=-1.887, p= 0.0295, one-tailed). Differences for untrained scripts in either language were nonsignificant.

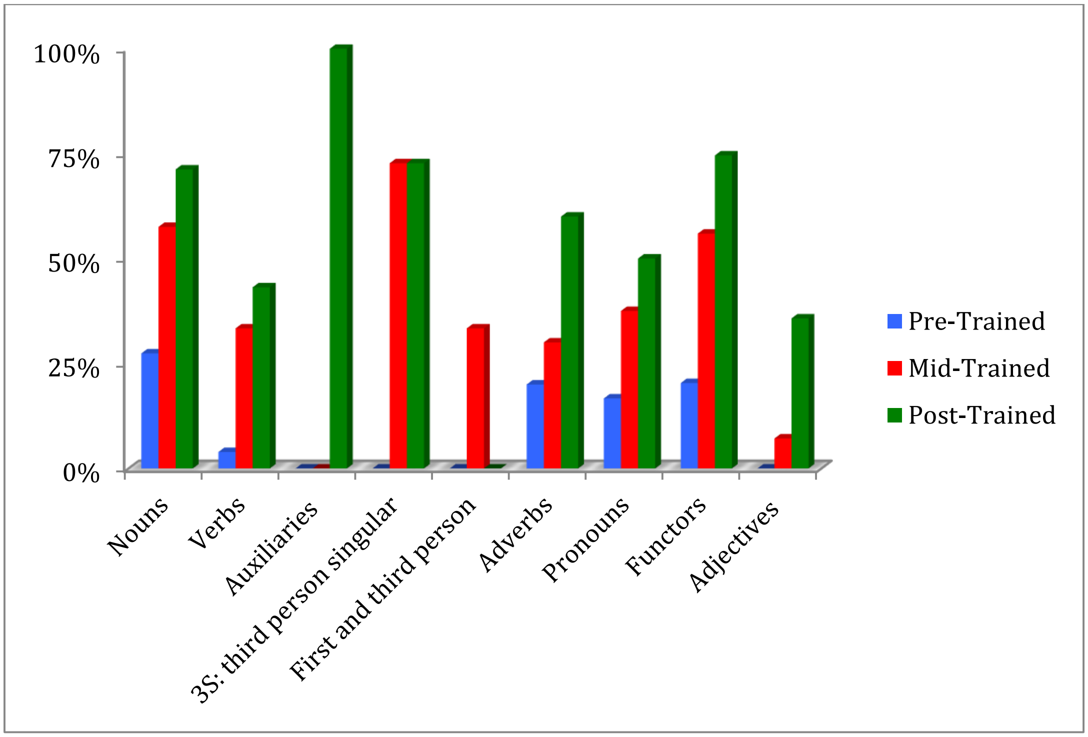

Figure 16. Percentage of Word Class Use Across Spanish Trained Scripts.

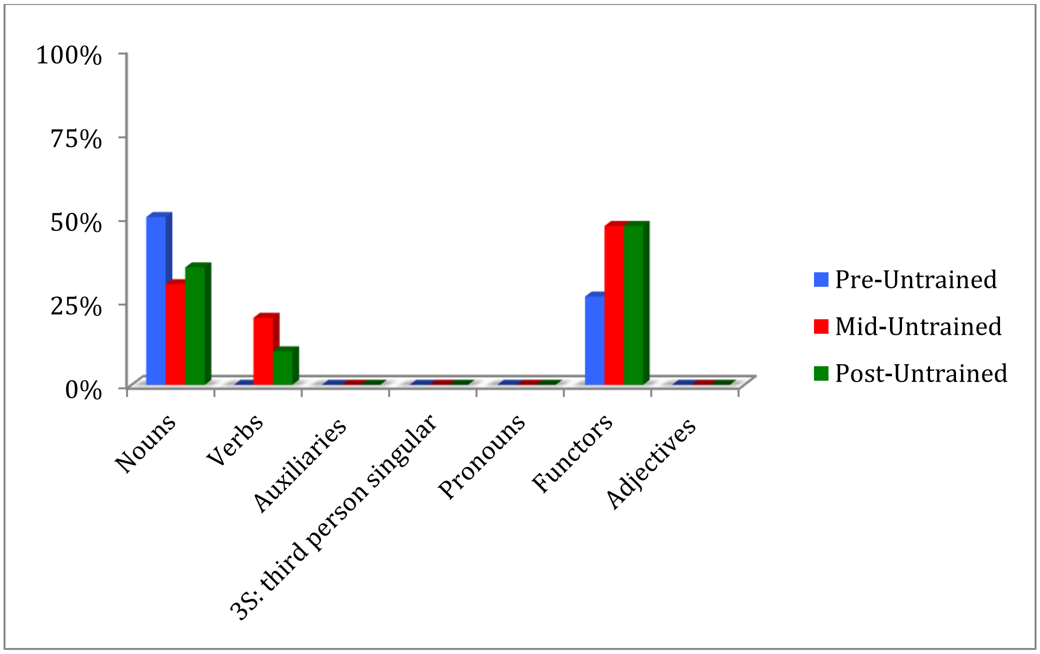

Figure 17. Percentage of Word Class Use Across Spanish Untrained Scripts.

3.2.6 Overall Intelligibility

The percentage of intelligible words produced was calculated before, during, and after treatment for trained scripts for English and Spanish. Overall intelligibility is defined as intelligibility of all words produced, regardless of whether the word existed in the script or not. RC's overall intelligibility for all scripts in either language was above 80% for pre-treatment time points. Therefore, Figures 18 and 19 show only modest improvements in intelligibility for all scripts, approximating 90% or greater, except for the Spanish-assigned cognate-dense script produced in English during the mid-treatment time point, in which intelligibility dropped to about 65% (Figure 18). Although RC was intelligible for single words at the start of treatment, the content of her message as a whole was often not received by listeners due to errors in word choice and order (e.g., RC produced sentences, such as "You had help me in any the mode that you can and you could.")

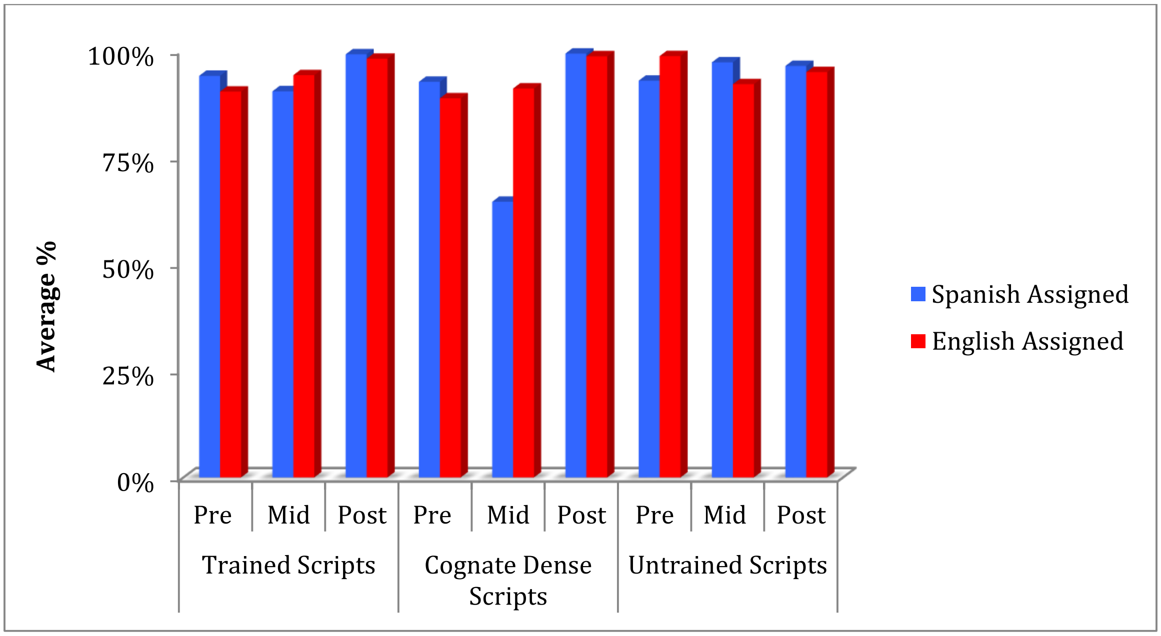

Figure 18. Overall Intelligibility for all Scripts Produced in English.

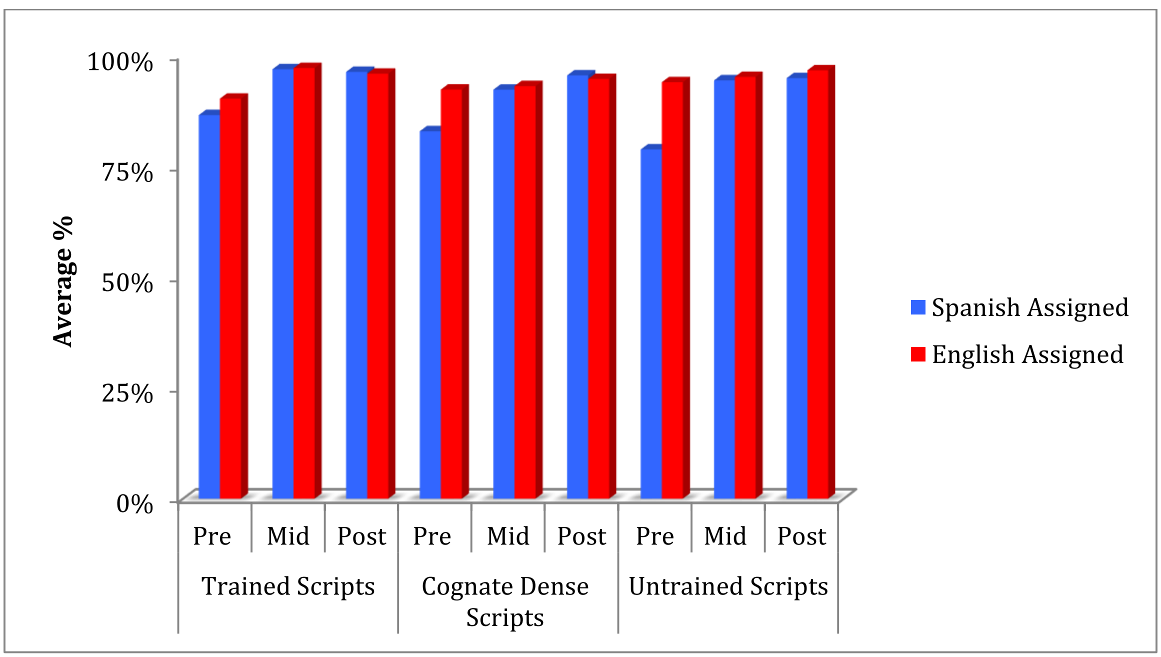

Figure 19. Overall Intelligibility for all Scripts Produced in Spanish.

3.3 POST-TREATMENT & FOLLOW-UP ASSESSMENTS

McNemar tests were used to compare pre- versus post-treatment, pre- versus mid-treatment, and mid- versus post-treatment time points on select language measures, including the *NAT* (Thompson, 2011) and two subtests of the *BAT* in English and Spanish (Paradis & Libben, 1987). Cochran tests were used to compare pre-, post-, and 3.5-month follow-up performance on the English and Spanish versions of the *BNT* (Kaplan, Goodglass and Weintraub, 2001; Kaplan, Goodglass, & Weintraub, 1986).

RC's performance on the *BNT* in English remained relatively stable, showing only mild improvement from pre-to mid-treatment time points with scores: 19/60 (pre-treatment) to 25/60 (post-treatment) to 22/60 (follow-up-treatment). These changes were not significant overall. However, performance in Spanish on the *BNT* (Kaplan, Goodglass, & Weintraub, 1986) showed a significant change as measured by a Cochran test ($Q(3)= 35.429$, $p<0.001$) after the course of treatment, increasing from 17/60 (pre-treatment) to 37/60 (post-treatment), and 41/60 at follow-up. McNemar tests were used for post hoc pairwise comparisons and revealed a significant change in performance from pre- to post-treatment, $p<0.001$, and from pre-to-3.5 month follow-up, $p<0.001$. A nonsignificant change in performance was observed from immediately post to 3.5 months post-treatment, $p=0.344$.

Performance on English syntax production on the *NAT* improved from pre- to post-treatment from a score of 4 of 12 (pre-treatment) to 8 out of 12 (post-treatment); however, these changes were not significant overall. Syntactic comprehension in English as measured by the *BAT* (Paradis & Libben, 1987) subtest revealed a nonsignificant change from pre-to-post-treatment (score of 61 to 57), with minimal improvement in Spanish (score of 58 to 64). Nevertheless, these changes were not significant overall. Similar results were observed on the *BAT* (Paradis & Libben, 1987) grammaticality judgment subtest for English and Spanish. Overall improvements (6 to 9, English; 7 to 10, Spanish; both scores out of 10) were not statistically significant. No significant changes in severity level of apraxia or dysarthria were observed on the Motor Speech Evaluation from pre- to post-treatment.

Other measures that saw improvement from pre-to post- treatment included the *WAB-R* (Kertesz, 1982; Aphasia Bank: Informal Spanish Translation, 2014) in both English (AQ 71.7 to 72.9) and Spanish (AQ 67.2 to 75.7). In summary, on generalization measures, RC showed improvement in various standardized measures from pre- to post-treatment, although only Spanish performance on the *BNT* (Kaplan, Goodglass, & Weintraub, 1986) was statistically significant.

IV. DISCUSSION

The purpose of this study was to examine the effects of script training in a bilingual (Spanish-dominant) participant with aphasia. This is the first study to treat a Spanish-English bilingual participant with aphasia using a video implemented script training treatment. The protocol utilized scripts that were personalized and tailored in content, rate of speech, and cognate status in each language. We investigated the effectiveness, as well as potential generalization within and across linguistic domains in a 66-year-old bilingual female (RC) with non-fluent aphasia resulting from an aneurysm in her left middle cerebral artery, with subsequent cerebrovascular accident during a left lateral frontal craniotomy. RC was pre-morbidly equally proficient in English and Spanish and post-morbidly Spanish-dominant.

Several hypotheses were generated regarding the potential effects of the treatment. It was predicted that RC would improve in the number of correct and intelligible words produced for scripted material within each language. Greater cross-linguistic generalization was expected from Spanish to English for scripted material, as well as for the scripts in each language that contained a high proportion of cognates.

In accordance with our hypothesis, treatment resulted in an increase in the number of correct and intelligible scripted words produced in the language of training. RC displayed a larger overall effect size for scripts treated in Spanish (d= 14.67), as compared with scripts treated in English (d=5.07; Robey et al., 1999; Beeson & Robey, 2006). Additionally, training in Spanish resulted in a greater degree of unidirectional cross-linguistic generalization to English, as well as greater within language generalization, as evidenced by improvement on confrontation naming on the Spanish *BNT* (Kaplan, Goodglass, & Weintraub, 1986). Minimal changes in the untrained control scripts occurred post-treatment, as these scripts were not directly targeted during VISTA treatment. As a result, it can be concluded that RC benefited from VISTA treatment, whose purpose was to create islands of relatively errorless, fluent speech to allow RC to communicate verbally on topics of personal importance. Following treatment, RC showed improved facility in word recall and increased production of phrases and syntactically correct sentence patterns in both trained languages.

Contrary to our hypothesis, however, scripts in both English and Spanish with a high proportion of cognates did not show a significant cognate facilitation effect, as both scripts yielded medium or small effect sizes (*d*=5.31 Spanish; *d*=2.67 English). Performance for the English-trained cognate script was only marginally better than performance on untrained scripts. It was noted, though, that the effect sizes for generalization from Spanish to English were greater with the inclusion of the cognate dense script for Spanish-trained scripts (*d*=16.13) compared with the effect size analysis that excluded the cognate-dense script (*d*=11.30). However, further analysis of the cognate scripts alone shows that this script generated the smallest effect sizes of treated scripts in Spanish. Although preliminary, this suggests that the participant's frontal lesion, and post-stroke dominance (Spanish > English) may have impeded the facilitation that is often observed with cognates. It is possible that, for our participant, who displayed deficits in executive functions and difficulty suppressing Spanish, a high proportion of cognates may have increased the competition between lexical units.

Secondary variables of interest included overall intelligibility, number of grammatical errors and interjections, and speech rate in WPM. These variables were calculated for selected time points before, during, and after treatment for trained scripts produced in English and in Spanish. Visual inspection and Wilcoxon signed-rank tests revealed significant differences and improvement in all secondary variables, particularly from pre- to post-treatment time points for trained scripts. In general, RC demonstrated greater gains, within and across languages, in her first acquired language (Spanish) relative to her later learned language (English) on trained scripts that were not cognate-dense. Spanish-assigned scripts saw a continual decrease in grammatical errors for trained scripts produced in English and Spanish, whereas English-assigned scripts were more variable. WPM increased from pre-to mid time points for both English and Spanish trained scripts (excluding cognate scripts) and tapered off slightly post-treatment. The frequency of interjections was also not consistent across languages. Scripts produced in English (Spanish and English-assigned) saw a steady decline in interjections across time points for trained and cognate-dense scripts. However, scripts produced in Spanish (Spanish or English-assigned) saw increases in interjections from pre-to mid time points for trained and cognate-dense scripts. Finally, RC saw vast improvement in production of different word classes across Spanish and English-assigned scripts relative to untrained scripts.

In general, there were overall significant differences and improvements for all secondary variables, with the exception of WPM. Whereas treatment was anticipated to increase the number of WPM from baseline to post treatment, it appears treatment had a greater impact on eliciting improvement in script content rather than rate, especially for cognate-dense scripts where RC experienced the lowest speech rate. Observation of graphical data reveals that script training of content incorporating an elevated percentage of cross-linguistic cognates in either language caused an increase in grammatical errors from pre to mid time points, especially for Spanish-assigned scripts produced in English. Furthermore, there was also an increase in the number of interjections produced for cognate dense scripts in both Spanish and English from pre- to mid-treatment time points relative to other scripts. Both cognate scripts (Spanish and English-assigned produced in both languages) had the highest number of grammatical errors post-treatment relative to trained and untrained scripts. Interestingly, RC was more likely to have a higher cognate accuracy percentage for trained scripts produced in both languages that were non-cognate dense.

The evidence for a cognate effect in bilingual aphasia therapy is not undisputed. Kurland and Falcon (2011), for example, reported an interference effect with cognates, following intensive naming therapy with a semantic approach, in the case of a Spanish-English bilingual with chronic and severe expressive aphasia. Researchers only saw a cross-linguistic transfer for non-cognates only, leading them to conclude that there was an interference of words with a similar phonological pattern that impeded target word activation. The authors utilize Green's Activation, Control and Resource Model (1986) to account for the interference effect of the cognates, which assumes that lexical selection of the target word requires a controlled balance of excitatory and inhibitory resources. Accordingly, the cognate advantage fades when cognitive control circuits are damaged, possibly due to reduced excitatory and inhibitory resources required to either activate the target or suppress the non-target. The impairment precludes correct selection among competing lexical units, such as cognates. Clearly, more research on the impact of brain injury on inhibitory mechanisms involved in switching between languages is warranted. Of particular importance are the degree to which such impairment affects a bilingual individual's capacity to access each language and how these factors influence treatment efficacy.

RC showed improvement after receiving therapy in both languages. However, greater generalization and treatment size effects were seen when therapy was administered in the language with higher post-morbid proficiency (Spanish), supporting previous findings in the literature (Kohnert, 2004). When comparing performance in one language versus the other(s), previous studies' results have supported the conclusion that training the non-dominant language improves cross-linguistic generalization (Kiran and Roberts, 2010; Edmonds and Kiran, 2006, Goral et al., 2012). Treatment in English resulted in large effect sizes for English trained scripts, excluding the cognate dense script assigned to English (d=5.83), as well as large effect sizes for generalization to Spanish (d= 7.74). The generalization from RC's L2 to L1 might support the findings of previous studies, however, we find that RC's stronger language led to greater cross language transfer. RC demonstrated larger gains from therapy administered in Spanish, corroborated by much larger effect sizes for Spanish-assigned scripts, as well as greater cross-language generalization to English. This is also the first study that shows cross-linguistic transfer can be inhibited when stimuli include a high proportion of cognates.

When we consider within-language manipulations, we see that, for RC's weaker pre-morbid language, cognates obstructed cross-linguistic transfer. It should be noted that previous studies provided treatment at the word level, whereas RC's treatment targeted connected speech. Other studies in the aphasia literature have found that there are likely to be more 'lexical candidates' competing for selection in connected speech than generative naming, resulting in higher processing demands in narrative tasks versus picture naming tasks (Ilshire & McCarthy, 2002; Law, Kong, Lai, & Lai, 2015).

RC's results, in which extensive improvements within and across languages were observed (although moreso in Spanish), are consistent with at least two theories of cross-linguistic generalization. The results seem to support either the RHM (Kroll & Stewart, 1994) or de Groot's *Mixed Model* (1992), which allow for language proficiency differences across bilingual individuals, with the latter allowing for more variability. In pre-morbidly equally proficient bilinguals, for example, de Groot's *Mixed Model* (1992) proposes equally strong connections from conceptual memory to both lexicons and between both lexicons. Accordingly, treatment in one language should result in generalization within the trained language, as well as to the untrained language. However, an individual more proficient in Spanish than English would have a weaker link between his/her English lexicon and the semantic system but a stronger link from the English to the Spanish lexicon. Therefore, the individual would rely more heavily on the link from the English to the Spanish lexicon to access the semantic system, making the act of speaking English a more complex process than speaking Spanish. This model could account for RC's higher effect sizes for Spanish relative to English treated scripts, as well as better performance on the cognate loaded script assigned to Spanish relative to the English-assigned cognate-dense script.

This study sheds light on the fact that cross-linguistic therapy effects depend on a number of factors, two of which are pre-and post-morbid proficiency. While treating the premorbid weaker language can result in cross-linguistic generalization, similar effects are also documented when therapy is provided in the stronger language post-morbidly or when proficiency after stroke is equivalent in both languages. Goral (2012) provides a more recent explanation of the role that language proficiency plays in cross-language treatment effects in four single-subject studies of multilingual individuals with aphasia. Consistent with our findings, in all cases, regardless of premorbid proficiency, cross-language generalization occurred when the therapy was offered in the language with higher post-morbid proficiency.

Specifically, there were cross-language effects between language pairs with approximately comparable proficiency (Case 1) and from a stronger treated language to a weaker untreated one (Case 2). Interestingly, Cases 2, 3 and 4 saw negative cross-language effects and evidence for global and local inhibition of a stronger untreated language following treatment of a language of lower proficiency. The results support the prediction that greater inhibition is applied to the stronger language than to the weaker language, regardless of the age of acquisition. The clinical implications of the findings reported by Goral (2012) include the likelihood that treating individuals in their weaker language (post-stroke) may impede performance in their stronger language, even if temporarily. In general, studies that depended on pre-morbid proficiency factors when deciding treatment reported cross-linguistic transfer of therapy effects from the premorbid weaker language to the stronger premorbid language. Conversely, studies that considered post-morbid proficiency factors revealed stronger cross-linguistic transfer of therapy effects when therapy was provided in the post-morbid stronger language and in some cases a negative cross-language effect following treatment in a language of lower proficiency (post-morbidly), which is more consistent with our findings.

An important clinical implication derived from this study is that video implemented script training may provide an efficient and effective treatment for non-fluent individuals. Daily homework was an essential component of this treatment program. RC conscientiously completed thirty minutes of homework every day over the course of treatment, while receiving direct contact with a clinician only twice a week. This is especially important considering that the duration of speech and language therapy services for many individuals with aphasia is often limited, and has promising implications for individuals facing limited reimbursement for treatment and for individuals who have mobility issues.

To summarize, this study suggests that bilingual individuals with aphasia can benefit from VISTA, with improved facility in word recall and increased production of phrases and syntactically correct sentence patterns. It also offers evidence that both languages can benefit from treatment, with a clear advantage for this participant's stronger post-morbid language and first acquired language. Various research studies to date have posited that cognates have greater cross-linguistic transfer relative to non-cognates, suggesting that the inclusion of cognates could bolster cross-linguistic transfer when clinicians treat in the patient's less proficient language. Nonetheless, our findings indicate that cognates interfere with, rather than facilitate target word selection, as well as impede cross-linguistic transfer when treating the patient's less proficient language. However, our results suggest that unidirectional cross-linguistic generalization for the Spanish-trained cognate-dense script was present, which yielded greater cross-linguistic transfer to English. Thus, cognates may bolster cross-linguistic generalization from the more proficient to the less proficient language, but render minimal cross-linguistic transfer for the reverse condition.

Consequently, clinicians delivering treatment in the weaker post-morbid language should be cautious when considering incorporation of a high proportion of cognates for treatment of patients with similar cognitive-linguistic profiles as our participant. It is unknown, however, whether the trends that we observed in this study specific to cognate-density and cross-linguistic generalization are related to the specific treatment approach we implemented or related to the unique lesion profile of this individual (with both frontal and temporal damage in the left hemisphere). Thus, future studies should manipulate cognate-density in different treatment approaches and with different patients to discern whether the respective competition and facilitation are attributable to bilinguals with acquired language impairment or whether the finding is specific to a given treatment approach or participant profile.

One of the shortcomings of treatment case studies in bilingual aphasia is that they have only one or two patients and only one pair of languages in each study. Additionally, the variability inherent in both aphasia and bilingualism make interpretations of results difficult. Given the extreme variability in the bilingual population, replicating findings from case studies may be of particular importance for informing clinical decisions in this population. Nevertheless, this study only sheds a small amount of light when considering the best treatment options for bilingual individuals with aphasia. The findings discussed may only be specific to RC's unique language profile and lesion site. RC sustained damage to semantic regions in the temporal lobe and frontal regions, which explain her difficulty with word retrieval and inhibition of incorrect word forms.

Clearly, a larger treatment sample is needed in order to corroborate these findings. The finding that therapy in this participant's stronger post-morbid language was more likely to produce generalized results to the weaker/later-acquired language, is potentially problematic for clinicians, given that a client's first language may not be shared with the clinician. Our results challenge the notion that training cognates may promote cross-linguistic generalization in post-stroke aphasia, at least in patients with similar cognitive-linguistics profiles as RC. As a result, it is important to consider multiple factors when deciding on language of treatment, including the client's preference, language of environment, pre-and post-morbid proficiencies, and the proportion of cognates in treatment sets. Further research that includes multiple individuals with various cognitive–linguistic profiles, specifically with different pairs of languages and varying patterns of language acquisition and use, is needed in order to develop the most effective clinical intervention programs for bilingual aphasia.

Appendix

Scripts Targeted for Treatment

Title	Assigned Language	# of Cognates	Total Words
Family	Spanish	1	29
About me	Spanish	4	32
Friends	Spanish	0	28
Familiar Constellations**	Spanish	16	34
Aphasia	English	2	31
Career	English	3	26
Religion	English	4	33
Rehabilitation**	English	14	38
Trips*	Spanish	5	34
Health*	English	3	30

* *Untrained*
** *Cognate dense*

Scripts by Number of Words, Sentences, and Readability

Scripts	**Flesch Kincaid Reading Ease**[1]	**No. of sentences**	**No. of words**	**Average words per sentence**	**Average syllables per word**
Script 1 *	34.1	5	29	5.8	2
Script 2 *	44.4	5	32	6.4	1.84
Script 3 *	33.6	4	28	7.09	1.96
Script 4 *, CD	34.7	4	34	8.25	2.64
Script 5 **	99.6	5	31	6.2	1.19
Script 6 **	80.9	4	26	6.5	1.42
Script 7 **	82.2	5	33	6.6	1.39
Script 8 **, CD	41.4	4	38	9.5	1.84
Script 9 *, UNT	100	4	34	8.5	1.82
Script 10 **, UNT	69.5	4	30	7.5	1.53

**Spanish-Assigned* *CD=Cognate-Dense* [1] *Reading score out of 100%*
***English-Assigned* *UNT=Untrained*

References

Aphasia Bank: Informal Spanish Translation (adapted from Spanish translation of WAB). (2014, August 18). Retrieved from http://talkbank.org/APhasiaBank/protocol/spanish/.

ASHA (2014). Demographic Profile of ASHA Members Providing Bilingual Services. The American Speech-Language-Hearing Association. Retrieved from: http://www.asha.org/uploadedFiles/Demographic-Profile-Bilingual-Spanish-Service-Members.pdf

Beeson, P. M., & Robey, R. R. (2006). Evaluating single-subject treatment research: Lessons learned from the aphasia literature. *Neuropsychology review*, *16*(4), 161-169.

Bernstein, R. (Ed.). (2012, May 17). Most Children Younger Than Age 1 Are Minorities. Retrieved from https://www.census.gov/newsroom/releases/archives/population/cb12-90.html

Bilda, K. (2011). Video-based conversational script training for aphasia: A therapy study. *Aphasiology*, 25(2), 191–201.

Breining, B. L., Lala, T., Martínez Cuitiño, M., Manes, F., Peristeri, E., Tsapkini, K.,... & Hillis, A. E. (2015). A brief assessment of object semantics in primary progressive aphasia. *Aphasiology*, *29*(4), 488-505.

Brookshire, R. (2007). *Introduction to neurogenic communication disorders* (7th ed.). St. Louis, Missouri: Mosby.

Caramazza, A., & Brones, I. (1980). Semantic classification by bilinguals. *Canadian Journal of Psychology/Revue canadienne de psychologie*, *34*(1), 77.

Chen, H. C., & Leung, Y. S. (1989). Patterns of lexical processing in a nonnative language. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*(2), 316.

Cherney, L.R., Halper, A.S., Holland, A. L., & Cole, R. (2008). Computerized script training for aphasia: Preliminary results. *American Journal of Speech-Language Pathology*, 17, 19-34.

Cherney, L. R., Halper, A.S., & Kaye, R.C. (2011). Computer-based script training for aphasia: Emerging themes from post-treatment interviews. *Journal of Communication Disorders, 44(*4), 493-501.

Cohen, N. S. (1992). The effect of singing instruction on the speech production of neurologically impaired persons. *Journal of Music Therapy*, 29(2), 87-102.

Costa, A., Santesteban, M., & Caño, A. (2005). On the facilitatory effects of cognate words in bilingual speech production. *Brain and language*, *94*(1), 94-103.

Costa, A., Caramazza, A., & Sebastian-Galles, N. (2000). The cognate facilitation effect: implications for models of lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*(5), 1283.

Crum, R.M., Anthony, J.C., Bassett, S.S., & Folstein, M.F. (1993). Population-based norms for the Mini-Mental State Examination by age and educational level. *JAMA,* 269(18), 2386-2391.

de Groot, A. M. B. (1992). Determinants of word translation. Journal of Experimental Psychology: Learning, Memory, and Cognition, 18, 1001–1018.

Dijkstra, T., & van Hell, J. G. (2003). Testing the language mode hypothesis using trilinguals. *International Journal of Bilingual Education and Bilingualism*, 6(1), 2–16.

Dijkstra, T., & van Heuven, W. J. B. (1998). The BIA model and bilingual word recognition. In J. Grainger & A. M. Jacobs (Eds.), *Localist connectionist approaches to human cognition*. Mahwah, NJ: Lawrence Erlbaum Associates.

Dijkstra, T., Grainger, J., & Van Heuven, W. J. (1999). Recognition of cognates and interlingual homographs: The neglected role of phonology. *Journal of Memory and language*, *41*(4), 496-518.

Dufour, R., & Kroll, J. F. (1995). Matching words to concepts in two languages: A test of the concept mediation model of bilingual representation. *Memory & Cognition*, *23*(2), 166-180.

Edmonds, L. & Kiran, S. (2006). Effect of semantic naming treatment on crosslinguistic generalization in bilingual aphasia. *Journal of Speech, Language, and Hearing Research, 49,* 729-748.

Faroqi-Shah, Y., Frymark, T., Mullen, R., & Wang, B. (2010). Effect of treatment for bilingual individuals with aphasia: A systematic review of the evidence. *Journal of Neurolinguistics*, *23*(4), 319-341.

Flesch, R. (1948). A new readability yardstick. *Journal of Applied Psychology*, *32*, 221-233.

Folstein, M.F., Folstein, S.E., & McHugh, P.R. (1975). “Mini-mental state”: a practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research 12(*3*)*, 189-198.

Fridriksson, J., Hubbard, H.E., Hudspeth, S.G., Holland, A.L., Bonilha, L., Fromm, D., & Rorden, C. (2012). Speech entrainment enables patients with Broca's aphasia to produce fluent speech. *Brain,* 135(12), 3815-3829.

Fridriksson, J., Basilakos, A., Hickok, G., Bonilha, L., & Rorden, C. (2015). Speech entrainment compensates for Broca's area damage. *Cortex*, *69*, 68-75.

Goldberg, S., Haley, K. L., & Jacks, A. (2012). Script training and generalization for people with aphasia. *American Journal of Speech-Language Pathology*, *21*(3), 222-238.

Goral, M. (2012). Cross-language treatment effects in multilingual aphasia. In *Aspects of Multilingual Aphasia*, (Vol. 8, pp. 106-121). Bristol, UK: Multilingual Matters.

Goral, M., Levy, E. S., Obler, L. K., & Cohen, E. (2006). Cross-language lexical connections in the mental lexicon: Evidence from a case of trilingual aphasia. *Brain and Language*, *98*(2), 235-247.

Goral, M., Rosas, J., Conner, P. S., Maul, K. K., & Obler, L. K. (2012). Effects of language proficiency and language of the environment on aphasia therapy in a multilingual. *Journal of Neurolinguistics*, *25*(6), 538-551.

Green, D. (1986). Control, activation and resource. *Brain and Language*, 27, 210-233.

Hermans, D., Bongaerts, T., De Bot, K., & Schreuder, R. (1998). Producing words in a foreign language: Can speakers prevent interference from their first language? *Bilingualism: language and cognition*, *1*(03), 213-229.

Hernandez, A. E., Dapretto, M., Mazziotta, J., & Bookheimer, S. (2001). Language switching and language representation in Spanish–English bilinguals: An fMRI study. *NeuroImage*, *14*(2), 510-520.

Howard, D., & Patterson, K.E. (1992). *The Pyramids and Palm Trees Test: A test of Semantic Access from Words and Pictures.* Thames Valley Test Company.

Ilshire, C. E., & McCarthy, R. A. (2002). Evidence for a context-sensitive word retrieval disorder in a case of nonfluent aphasia. Cognitive Neuropsychology, 19, 165–186.

Kaplan, E., Goodglass, H., & Weintraub, S. (1986). Test de vocabulario de Boston. Panamericana.

Kaplan, E., Goodglass, H., & Weintraub, S. (2001). Boston Naming Test—2nd Ed. Austin, TX: Pro-Ed.

Kertesz, A. (1982). Western aphasia battery test manual. Psychological Corporation.

Kertesz, A., & Poole, E. (1974). The aphasia quotient: The taxonomic approach to measurement of aphasiac disability. *The Canadian Journal of Neurological Sciences*, 1 (1), 7-16.

Kiran, S., & Edmonds, L. A. (2004). Effect of semantic naming treatment on crosslinguistic generalization in bilingual aphasia. *Brain and Language*, 91(1), 75-77.

Kiran S., Peña E, Bedore L, Sheng L. (2010). Evaluating the relationship between category generation and language use and proficiency. Paper presented at the Donostia Workshop on Neurobilingualism; San Sebastian, Spain.

Kiran, S. & Roberts, P.M. (2010). Semantic feature analysis treatment in Spanish-English and French-English bilingual aphasia. *Aphasiology, 24(2),* 231-261.

Kirsner, K., Lalor, E., & Hird, K. (1993). The bilingual lexicon: Exercise, meaning and morphology. *The bilingual lexicon*, 215-248.

Kohnert, K. (2004). Cognitive and cognate-based treatments for bilingual aphasia: A case study. *Brain and Language*, 91, 294-302.

Kramer, J.H., Jurik, J., Sha S.J., Rankin, K.P., Rosen H.J., Johnson J.K., (2003). Distinctive neuropsychological patterns in frontotemporal dementia, semantic dementia, and Alzheimer disease. *Cognitive and Behavioral Neurology*, 16(4): 211-218.

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of memory and language*, *33*(2), 149-174.

Kurland, J., & Falcon, M. (2011). Effects of cognate status and language of therapy during intensive semantic naming treatment in a case of severe nonfluent bilingual aphasia. *Clinical linguistics & phonetics*, *25*(6-7), 584-600.

MacWhinney, B. & Snow, C. (1985) The Child Language Data Exchange System. *Journal of Child Language*, *12,* 271-296.

Lalor, E, & Kirsner, K. (2001). The role of cognates in bilingual aphasia: Implications for assessment and treatment. *Aphasiology*, *15*(10/11), 1047-1056.

Laganaro, M., & Overton Venet, M. (2001). Acquired alexia in multilingual aphasia and computer-assisted treatment in both languages: Issues of generalization and transfer. *Folia Phoniatrica et Logopaedica, 53*, 135-144.

LaPointe, L. (2011). Multicultural and Multi-Linguistic Issues. In *Aphasia and related neurogenic language disorders* (4th ed., pp. 69-79). New York: Thieme.

Law, S. P., Kong, A. P. H., Lai, L. W. S., & Lai, C. (2015). Effects of context and word class on lexical retrieval in Chinese speakers with anomic aphasia. *Aphasiology*, *29*(1), 81-100.

Lee, J. B., Kaye, R. C., & Cherney, L. R. (2009). Conversational script performance in adults with non-fluent aphasia: Treatment intensity and aphasia severity. Aphasiology, 23(7–8), 885–897.

Lorenzen, B., & Murray, L. L. (2008). Bilingual aphasia: A theoretical and clinical review. *American Journal of Speech-Language Pathology*, *17*(3), 299-317.

Online Readability Calculator - Flesch Kincaid, Gunning Fog and more ... (n.d.). Retrieved March 18, 2016, from https://readability-score.com/.

Paradis, M. (1977). Bilingualism and aphasia. Whitaker, H., Whitaker, H. *Studies in neurolinguistics*. *3* 65–121 New York Academic Press.

Paradis, M., & Libben, G. (1987). The assessment of bilingual aphasia. Mahwah, NJ: Lawrence Erlbaum Associates.

Peña-Casanova, J., Blesa, R., Aguilar, M., Gramunt-Fombuena, N., Gómez-Ansón, B., Oliva, R., ... & Martínez-Parra, C. (2009). Spanish multicenter normative studies (NEURONORMA project): Methods and sample characteristics. *Archives of Clinical Neuropsychology*, *24*(4), 307-319.

Potter, M. C., So, K. F., Von Eckardt, B., & Feldman, L. B. (1984). Lexical and conceptual representation in beginning and proficient bilinguals. *Journal of verbal learning and verbal behavior*, *23*(1), 23-38.

Racette, A., Bard, C., & Peretz, I. (2006). Making non-fluent aphasics speak: sing along!. *Brain*, *129*(10), 2571-2584.

Rami, L., Serradell, M., Bosch, B., Caprile, C., Sekler, A., Villar, A., ... & Molinuevo, J. L. (2008). Normative data for the Boston Naming Test and the Pyramids and

Palm Trees Test in the elderly Spanish population. *Journal of Clinical and Experimental Neuropsychology*, *30*(1), 1-6.

Roberts, P. M., & Deslauriers, L. (1999). Picture naming of cognate and non-cognate nouns in bilingual aphasia. *Journal of Communication Disorders*, *32*(1) 1-22.

Robey, R. R., Schultz, M. C., Crawford, A. B., & Sinner, C. A. (1999). Single-subject clinical-outcome research: designs, data, effect sizes, and analyses. *Aphasiology*, 13, 445–473.

Schlaug, G., Norton, A., Marchina, S., Zipse, L., and Wan, C. (2010). From singing to speaking: Facilitating recovery from non-fluent aphasia. *Future Neurology*, 5(5) 657-665.

Thompson, C.K. (2011) *Northwestern Assessment of Verbs and Sentences.* Evanston, IL: Minuteman Press.

Tombaugh, Tom T. N., & Hubiey, A.M. (1997). The 60-item Boston Naming Test: Norms for cognitively intact adults aged 25 to 88 years. *Journal of Clinical and Experimental Neuropsychology, 19*(6), 922-932.

U.S. Bureau of the Census. (2013). Language Use in the United States: 2011 American Community Survey Reports. https://www.census.gov/prod/2013pubs/acs-22.pdf.

U.S. Bureau of the Census. (2014). Annual Estimates of the Resident Population by Sex, Race, and Hispanic Origin for the United States. http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk.

Weintraub, S., Mesulam, M. M., Wieneke, C., Rademaker, A., Rogalski, E. J., & Thompson, C. K. (2009). The northwestern anagram test: measuring sentence production in primary progressive aphasia. *American journal of Alzheimer's disease and other dementias*.

Wertz, R.T., LaPointe, L.L., & Rosenbek, J.C. (1984). *Apraxia of speech in adults: The disorder and its management.* Orlando, FL: Grune & Stratton.

van der Meulen, I., van de Sandt-Koenderman, M. E., & Ribbers, G. M. (2012). Melodic intonation therapy: present controversies and future opportunities. *Archives of physical medicine and rehabilitation*, *93*(1), S46-S52.

Van Heuven, W. J., Dijkstra, T., & Grainger, J. (1998). Orthographic neighborhood effects in bilingual word recognition. *Journal of memory and language*, *39*(3), 458-483.

Yamaguchi, S., Akanuma, K., Hatayama, Y., Otera, M., & Meguro, K. (2011). Singing therapy can be effective for a patient with severe non-fluent aphasia. *International Journal of Rehabilitation Research, 35*, 78-81.

Youmans, G., Holland, A., Munoz, M.L., & Bourgeois, M. (2005). Script training and automaticity in two individuals with aphasia. *Aphasiology, 19, 435-450.*

Youmans, G., Youmans, S.R., & Hancock, A.B. (2011). Script training treatment for adults with apraxia of speech. *American Journal of Speech-Language Pathology, 20*, 23-37.