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Research Paper

Contributions of Pre and Postmorbid Nondominant Language Interventions to Coactivation of L1-L2 Lexical Representations: A Case Study of Persian-English Bilingual Stroke-Induced Aphasic Patients

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Abstract

The current study sought to bring into light the important functions of pre and postmorbid nondominant language interventions and aphasia patients' level of L1-L2 proficiency considering the productive dimension of vocabulary knowledge affected by intertrial tasks. Two Persian-English bilingual cases with anomia and different levels of postmorbid L2 proficiency were subjected to a treatment of English naming to find the contribution of English naming improvement to Persian naming. Both cases were given the therapeutic language intervention to enhance their naming performance of English lexical items and to find out whether it could be generalized to Persian equivalents. Data obtained from the 2 participants were analyzed using semantic naming tests, and the responses were validated through time-series analysis. Statistical findings suggested that participant 1, who had a higher L2 proficiency, exhibited higher performance than participant 2 throughout 5 consecutive trials, once they had received phonemic cues after semantic ones. Concerning within-language impacts, treated items exhibited a considerable improvement. The treated items and repeated untreated ones improved concerning cross-language impacts.

Keywords: Lexical Retrieval; L1-L2; Pre and Postmorbid Language Proficiency; Nondominant Language; Stroke-Induced Aphasia; Anomia

1. Introduction

Understanding the multifaceted phenomenon of language configuration at the brain level in bilingual people is rather difficult but ongoing (Kroll, Dussias, Bogulski, & Kroff, 2012). Cerebrovascular accident (henceforth, CVA) cause more brain-damaged bilingual speakers due to the sharp increase in the number of people who can speak two or more languages around the world, as well as changes in the modern lifestyle (de Freitas, 2012; Hallowell & Chapey, 2008). Some bilingual people can present a similar type of aphasia for L1 and L2, whereas some others may develop different types of aphasia for L1 and L2. Several factors have been proposed as the causes for the differences in the symptoms presented for the two languages, including the age of learning each language, the competency level for each language, the level of using the languages in everyday life, and the structural differences between the two languages (Ansaldo, Marcotte, Scherer, & Raboyeau, 2008). Evaluating bilingual aphasia can highlight the processing, configuration, and organization of language in people who speak two languages, while providing information on the different impacts of brain damage on each of the languages (Altman, Goral, Levy, 2012; Hope et al., 2015). Differently stated, the evaluation of patients with bilingual aphasia allows exploration of the effects of brain damage on two different languages in the brain, thus allowing scholars to systematically test various facets of this dynamic process.

There are many complex points when investigating these patients. As the language learning experience is unique to each individual, the level of immersion in both languages will determine the level of the expression of each person's linguistic deficits (Ehl, Bruns, & Grosche, 2020; Nanchen et al., 2017). Although in monolingual aphasia, it is assumed that the individual was probably highly competent in using his or her language before the aphasia-causing stroke, with regards to bilingual aphasia, scholars cannot assume any level of proficiency for the bilingual individual in either of the two languages. Therefore, in such cases, scholars may have to use a language use questionnaire to determine an individual's proficiency level. Because both bilingualism and aphasia are dynamic phenomena, the findings of studies on patients with bilingual aphasia may vary widely. Particularly, because there are many factors related to language proficiency that may affect our judgment of the language status of a bilingual patient even before the stroke, it may be highly difficult to determine the level of poststroke linguistic deficits. Therefore, people with mostly similar prestroke language learning backgrounds may develop highly different levels of poststroke language difficulties.

On the other hand, the opposite may also be true, that is, individuals with different language proficiency levels before the stroke may develop similar poststroke language difficulties (Kiran & Roberts, 2012; Peñaloza & Kiran, 2019). L2 learners' age and level of proficiency are significant factors affecting the representation of language in healthy bilingual individuals. Exploring the condition of bilingual aphasia may seem very difficult when considering other factors, including the size and site of the lesions seen in aphasia and brain damage. Therefore, currently, our knowledge about the condition of bilingual aphasia only covers the rate of linguistic difficulties and a brief understanding of a wide range of factors affecting the status of deficits (Goral & Lerman, 2020; Kong, Abutalebi, Lam, & Weekes, 2014; Nilipour & Ashayeri, 1989; Sasanuma, 1995). However, there are hopes of reaching rational interpretations through the exploration of various levels of linguistic deficits among these patients.

The major treatment for people with bilingual aphasia involves language intervention in one of the languages of the individual. There have been many studies investigating whether the improvement in producing and understanding of one language after treatment of aphasia patients leads to improvement in the other language, the results of which are sometimes contradictory (e.g., Faroqi-Shah, Frymark, Mullen, & Wang, 2010; Kohnert & Peterson, 2012). Some studies have shown that the improvement in one language leads to improvement in the other language, as well (e.g., Kiran & Iakupova, 2011). However, some other studies have shown no change in the L2 after improvement in the L1 in people with bilingual aphasia (e.g., Keane & Kiran, 2015). Many of these studies show a cross-language generalization of the improvement for certain outcome measures (e.g., Altman et al., 2012), for some languages left untreated (e.g., Miertsch, Meisel, & Isel, 2009), and for participants (e.g., Kiran & Roberts, 2010).

As a case in point, Goral, Levy, and Kastl (2010) conducted a study on an English-, French-, and Hebrew-speaking patient affected by a left CVA. The patient had mild aphasia in all three of his spoken languages. The focus of the treatment was on English morphosyntactic structures in sentence formation, which was his L2. After the treatment, the tests showed improvement in several indicators for language formation in English. Moreover, there was a level of improved grammatical accuracy for his L3, which was French. For example, he had a higher capability for correctly using prepositions and pronouns. However, there was no significant improvement in other aspects, such as using articles and the rate of producing sentences.

Furthermore, there were no significant changes in the morphosyntactic structures for his L1 (which was Hebrew), whereas there was an improvement for other measures of producing speech, including grammatical structures of sentences and narrative structures. In a similar study, a multilingual speaker was treated for her L4 (Knoph, Lind, & Simonsen, 2015). The study showed contradictory results for cross-language generalization to other languages she spoke. For example, she had an improved performance in English, her L2, in the semantic and syntactic sections of the Bilingual Aphasia Test (BAT), but not in naming verbs, or variables associated with sentences and the discourse for producing connected speech.

Croft, Marshall, Pring, and Hardwick (2011) conducted a study on cross-language generalization using five English- and Bengali-speaking participants with bilingual aphasia. The study involved two therapy phases, one phase for each of the two languages in a sequential manner. The participants were patients born in Bangladesh, but they were living in England. All of the patients had a left CVA, at least, 6 months before the study, which resulted in aphasia. All the patients were experiencing deficits in retrieving words in both languages. The intervention involved semantic and phonological strategies for improving word retrieval. The patients underwent many tests for naming pictures before and after the treatment process. Their findings showed that two of the patients responded well to semantic interventions, showing improvement in both English and Bengali.

On the other hand, four of the patients responded well to the phonological intervention; however, one showed improvement only in Bengali, which was her L1. It is worth noting that one of the patients did not show any improvement after the intervention. More importantly, after the semantic-based intervention, three of the five patients showed cross-language generalization to the untreated language. In a similar study by Kiran and Roberts in 2010, only one of the four patients who under intervention showed cross-language generalization after the intervention.

The unclear results provided by the above studies with regards to the cross-language generalization of the intervention lead to some questions, including what to use to predict the realization of cross-language generalizations and how to predict them. Domain-focused intervention (e.g., retrieval of words vs. morphosyntactic structures, e.g., Altman et al., 2012), the level of similarities between the languages (e.g., if the languages are from the same family like Catalan and Spanish, or from different language families like Chinese and English; e.g., Ansaldo & Saidi, 2014; Goral et al., 2010; Lewis, Simons, & Fennig, 2015), and the competency as well as the level of using each language by the patients before and after the development of aphasia (Kuzmina, Goral, Norvik, & Weekes, 2019) are the commonly proposed variables as predictors of cross-language generalizations.

Compared to interventions that target specific lexical items or syntactic structures, interventions focusing on underlying processes such as semantic organization or overall competency for producing language might be effective for the development of cross-language generalization. Nevertheless, the majority of intervention-based studies focus on the results of specific treatment targets such as retrieving words (e.g., Croft et al., 2011). Only a limited number of such studies have presented the results related to untreated aspects, including severity level, overall test scores, or generalization to the production of connected speech (Altman et al., 2012). Therefore, there is little information on the changes in overall competency for producing language among patients who speak two languages and suffer from mild aphasia.

To determine the probability of cross-language generalization after treatment, one of the variables proposed as a suitable variable is proficiency in the language. However, studies presenting predictions using this variable have mixed results and varied predictions. In particular, reports show that cross-language generalization is more probable when the patient has similar levels of proficiency in both languages (Conner et al., 2018; Goral, 2012), from a weaker language to a stronger language (Barrett, 2018; Edmonds & Kiran, 2006), or from a stronger language to a weaker language (Goral, 2012). Many studies have shown that language proficiency does not play a significant role in predicting cross-language generalization (Knoph, 2013).

Goral et al. (2010) argue that cross-language impacts may lead to the generalization of the advantages of the intervention; however, they also suggest that this may increase the competition between languages, thereby creating transitory adverse cross-language impacts. This notion, which is in line with Green’s inhibitory control theory (1998), may explain why some studies report no improvement after the intervention (e.g., Abutalebi, Della Rosa, Tettamanti, Green, & Cappa, 2009). In other words, both of these types of impacts may be influential, namely, the cross-language generalization of the outcomes of the intervention is mitigated by the reduced activation levels of the language left untreated. It is not clear yet how the generalization of positive cross-language impacts, adverse impacts created by higher activation levels of the treated language, and lower activation level of the untreated language may work together to result in the findings of such studies.

On this basis, the main objective of the present study was to investigate the likelihood of possible variations in the average performance profile of anomic aphasic bilingual patients on immediate and delayed lexical trials. More specifically, this study tended to describe the actual mechanism of processing involved in the L1-L2 mental lexicon by addressing two different complementary questions. Initially, it looks at how pre and postmorbid nondominant language treatments in aphasic patients affect their L1-L2 lexical access. Next, it looks at the possible relationship(s) between the stroke-induced aphasic patients’ level of L1-L2 proficiency and their lexical retrieval patterns. A word of caution deems necessary here. Before moving on, it would be appropriate to explore the assumptions underlying the data analysis: (a) Treatment will result in improved retrieval of trained English words; (b) treatment will result in improved retrieval of Persian translations of trained words; (c) treatment will result in improved retrieval of untrained, semantically related words in English; (d) treatment will result in improved naming of Persian translations of untrained and semantically related words; (e) and more balanced proficiency in both of their languages will result in more significant naming gains in both languages.

2. Methodology

A retrospective-prospective cohort research design was utilized to bring into light the important functions of pre and postmorbid nondominant language interventions. Stroke-induced aphasic patients' level of L1-L2 proficiency considering their receptive and productive dimensions of lexical knowledge was influenced by intertrial tasks and mediator involvement were also other concerns of the study. To this end, a case-based research approach was adopted.

2.1. Participants

The participants were two right-handed Persian-English bilinguals of Iranian descent. They were called by speech-language pathologists from local-area hospitals, through a mass e-mail and informational flyer distributed by the researchers. A severe left temporal lobe ischemic stroke following left middle cerebral artery occlusion was the etiology for aphasia in the two cases. This area is important in many language functions like lexical access. The participants and procedures were approved by the Institutional Review Board at Isfahan University of Medical Sciences. Both participants were briefed on the risks and benefits of the study and signed an informed consent statement before participating in the study. The two participants signed the informed consent to get structural research MRI scans for use in other studies at the time of original scanning.

2.1.1. Case Description

2.1.1.1. Participant 1

The first participant (hereafter, P1) was 53 years-old-man who had had a left temporoparietal stroke 39 months before the study and an unspecified right-hemisphere stroke 84 months before the study. His proficiency in English and Persian was almost equal because he had learned Persian as his L1, whereas he had learned English in the community.

2.1.1.2. Participant 2

The second participant (hereafter, P2) was a 58-years-old man who had had a left frontoparietal stroke 6 months before the study. He was more proficient in Persian than English and had started learning English as an adult. He had completed high school in Iran, and when he was an adult, his family had moved to the U.S. with him.

2.2. Instrumentation

2.2.1. Pre and Postmorbid Dominant Languages

To quantify the pre and postmorbid dominant language abilities for both participants (see Figure 1), the bilingual proficiency ratio (BPR) was computed, as follows:

$$\text{BPR} = \frac{\text{L1 comprehension} + \text{reading} + \text{writing} + \text{speaking}}{\text{English comprhension} + \text{reading} + \text{writing} + \text{speaking}}$$

In other words, BPR is calculated by dividing the sum of various ratings made by the participant for himself in the L1 by the sum of ratings made for English. The participant has equal proficiency in both languages if BPR =1.0, the L1 is dominant if BPR >1.0, and his English is dominant if BPR < 1.0.

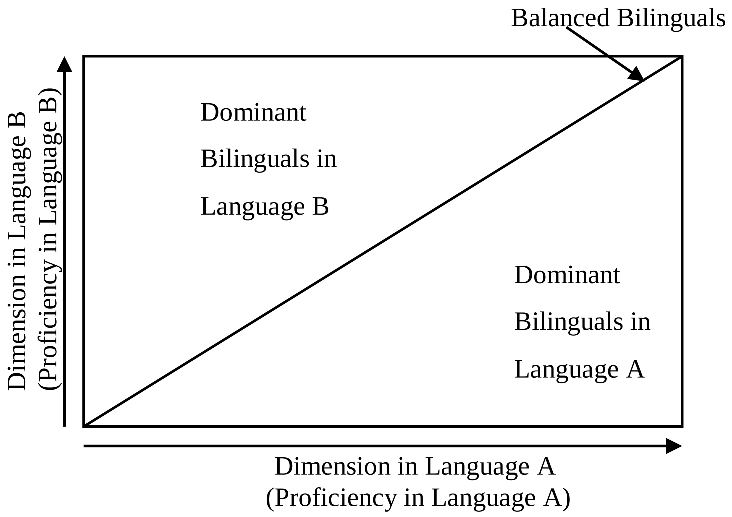

Figure 1. A Schematic Representation of Language Dominance in Bilinguals

2.2.2. Postmorbid Language Proficiency

Before measuring the baseline levels, the participants completed several tests and questionnaires, including the Boston Naming Test (BNT; Farsi version, Ramezani et al., 2020) and Bilingual Aphasia Test (BAT; Farsi version, Paradis, Paribakht, & Nilipour, 1987). Also, the auditory comprehension, repetition, naming, and spontaneous speech subsections of Western Aphasia Battery (WAB; Kertesz ,1982), as well as auditory synonym judgments and spoken word-picture matching subsections of Persian Aphasia Naming Test (Nilipour, 2012) were used.

The tests and questionnaires were used to evaluate the intensity and type of aphasia and poststroke proficiency in each language (Edmonds & Kiran, 2006; Kiran & Roberts, 2010). The WAB-based aphasia quotients (AQ) for the participants showed that they had severe aphasia highlighted by difficulty in repetition and naming items.

2.3. Procedure

2.3.1. Determining Individual Word Lists

Individualized word lists were prepared for each case based on the participants' difficulty in naming words consistently. In the baseline sessions, we showed them 200 stimulus pictures, which were extracted from the Persian Picture Naming Battery (PPNB, Nilipour, 2012), based on conceptually related and unrelated pairs of picture-word stimuli. The participants were to name the pictures in both languages. There were four different word sets based on the baseline results: (1) Ten trained English words referred to as the first set of English words, (2) Persian translations of the English words referred to as the first set of Persian words, (3) 10 untrained English words referred as the second set of English words and, finally, (4) Persian translations of the English words referred to as the second set of Persian words. Moreover, five untrained English words and five untrained Persian words were considered, without any relationship with the other word sets used in the treatment. The 10 unrelated words were the control words to measure treatment effectiveness. Each word set comprised of one- to four-syllable words with a 'more frequent' to 'most frequent' label in the PPNB. A stimulus picture accompanied each word. At first, the stimulus pictures were displayed on a 14-inch laptop. However, after selecting the word lists, the 10 treatment stimuli pictures were printed on white cards for the treatment sessions through color printing.

2.3.2. Developing Semantic Features for Treatment

Before the treatment, six semantic features were identified for each item like *dog*, according to the studies carried out by Kiran and Roberts (2010) and Edmonds and Kiran (2006). These features concerned the following categories: the item's subordinate category, such as animal, its function, such as protecting a house; its physical characteristics, such as having fur, its places, such as a kennel, its relationship with each participant, such as what it reminded the participant of, and its general characteristics like barking. The relationships with the items were determined during three successive sessions with the participants and a therapist. We also created six distracting characteristics for each item to be used during the treatment.

2.3.3. Baseline Measures

We used a confrontational naming task in Persian and English for collecting baseline data for both participants. Each participant completed three tasks before the treatment with a minimum of a one-week interval, as well as four and six weeks after the treatment, to obtain multiple measurements for each participant. Then, we showed a set of 200 stimulus pictures with random complexity and length, and words accompanying the pictures to the participants in the baseline session. In these tasks, the participants were to identify the pictures in one language and, then, in the other language. However, the languages were counterbalanced in various baselines to prevent them from appearing in the same order. When the participants showed the ability to name the stimuli in either of the languages, the stimuli would be excluded to gradually reduce the number of stimuli presented to them during consecutive baseline sessions. After the completion of the third baseline session, 30 stimulus pictures were identified based on the fact that the participant had problems naming them in either of the languages during the three sessions. The 30 pictures comprised treatment stimuli for each participant and matched the six-word sets described before.

2.3.4. Treatment

A monolingual English-speaking undergraduate student, who was studying the Speech-Language Pathology Program at Isfahan University of Medical Sciences and was trained for the present study, administered the treatment for P1 under the supervision of a certified speech-language pathologist. The bilingual researcher performed the pretreatment tests for the participants and observed outcomes through face-to-face sessions or recordings to ensure the data. He administered all the pre and posttests and treatments for P2 under the supervision of a certified speech-language pathologist. Both participants used Persian to interact with the researcher, although they had been told to speak English with the researcher. This issue will appear in detail in the Results and Discussion section.

2.3.5. Treatment Sessions

The location for all the tests and treatment sessions was the participant’s house. The treatment was conducted only in English based on the semantic feature analysis (SEA, Boyle, 2010; Boyle & Coelho, 1995). The SEA technique works by asking the participant to name the semantic features of an item. This type of analysis increases the chance for the activation of the target lexical item in the brain, thus facilitating retrieval for the participant.

The treatment procedures were similar to those proposed by Kiran and Roberts (2010). We showed five semantic features for each word to the participants. For instance, for the word *dog*, the participants gave the following features: the item’s subordinate category, such as animal, its function, such as being a pet, its physical characteristics, such as having four legs, its location, such as living in a house close to people, and its general characteristics, such as being furry. The participants were, then, asked to come up with additional features involving their relationships with the item, such as “a dog reminds me of . . .” with the help of the clinician. Moreover, six distracting features not related to the target word were added to the word lists.

For the treatment, a picture was shown to the participants to come up with the name of the target item. In case they failed to name it without help, they could represent it with a phonemic cue. Regardless of whether they correctly named the item after receiving the cue, the same picture was, then, presented to them with the name written below it, and they were asked to repeat the name two times. After examining the picture, a set of 12 cards was given to them: six cards with the target semantic features written on them and six distracting cards. Then, they were asked to select the features relevant to the target item among the twelve cards. The clinician would read the words aloud while showing the words with a finger to mitigate the participants’ alexia, and they were to choose whether the feature was related to the target. Afterward, the card was placed face down, and the participants were asked to answer 12 yes/no questions related to the features of the target item. These questions included, for instance, “Is the target an animal?” and “Is it kept in a fridge?” In the end, the image was presented to the participants again to name the target item 2-5 times. The repetitions were established for introducing phonological stimulation (Raymer, Thompson, Jacobs, & Le Grand, 1993).

Each participant received treatment once or twice a week, according to the procedures described by Edmonds and Kiran (2006). However, because of multiple cancellations, there were some long breaks between the sessions for P1. The breaks were as follows: a 2-week break between sessions # 7 and 8, a 2-month break between sessions # 10 and 11, a 2-week break between sessions # 12 and 13, and a 2-week break between sessions # 15 and 16.

2.3.6. Trials

After every two sessions, the tests were given to the participants to evaluate their progress. P1 took nine tests, whereas P2 completed 10 tests. Four words from the six-word lists of the baseline measurements appeared in the tests, but the 10 control words did not.

The tests evaluated the items taught to the participants. They also measured the semantically related words in each language, that is, the words the participants did not receive training to detect the occurrence of generalization to the semantically related words. After the treatment sessions, the tests, which included the 10 control words, were used to measure the treatment effectiveness. Six weeks after the intervention, the participants took a maintenance test to determine the durability of the results.

2.4. Data Analysis Methods

The primary dependent measure was the participants' responses to the semantic naming tests (Edmonds & Kiran, 2006). After a 20-session treatment, if the performance levels increased, at least, 40% higher than the baseline across two successive sessions, generalization would be confirmed. A time-series analysis based on the C statistic was used to test the reliability of the changes from baseline to treatment (Fabio, Castelli, Marchetti, & Antonietti, 2013; Tryon, 1982).

2.4.1. Scoring and Analysis

The accuracy of the initial responses was used to measure performance. The correct and incorrect responses received the scores of 1 and 0, respectively. The word scores were extracted from three-session repetitions and, then, for each set, the scores of the posttest and baseline tests and those related to follow-ups and baseline tests were compared. Improvement measurements were performed by the analyses of McNemar test. The analyses computed positive and negative changes, disregarding those with no changes in the conditions. The process was constrained by the number of items attempted by the participants during a session. Considering the small number of testable cognate (13) and noncognate (13) values in the Persian translation and English treated sets, a clear approach, the minimum follow-up, and posttest scores, differences in the follow-up and posttest scores were integrated for such items to boost the statistical power.

Also, the analyses included differences in the distribution of each error type between the posttest and the baseline test and between the follow-up and the baseline test (i.e., no response, correct translation, circumlocutions, semantic, initial phoneme, and morphology). The chi-square tests were employed to measure the differences in the distribution of error types in each set.

3. Results and Discussion

3.1. Identifying Pre and Postmorbid Dominant Languages

Whereas the BPR belonging to P1's score was less than 1.0 (i.e.,0.96) because he claimed he had learned English but not Persian in school, he still could read and understand simple Persian words along with the English words. On the other hand, the majority of his communications with other people were in Persian because he was living in a small Persian community. Hence, concerning the purposes of the current study, his levels of proficiency were similar in both languages.

Moreover, P2's BPR score was 1.98, indicating the significant superiority of Persian to English. He had learned Persian in school (when he was a child) and English in adulthood. However, he believed he was not capable of reading well in both languages and would rarely write anything except when he had to fill out different forms and sign his name.

3.2. Establishing Postmorbid Language Proficiency

Whereas P1 had relatively high fluency in speech, he had almost complete alexia and anomia. On the other hand, his ability to repeat beyond the word level had been significantly reduced; he exhibited an inconsistent capability to repeat single words. Because P1's fluency was relatively high with the capability for basic auditory comprehension, his difficulty in repeating words could highlight his conduction-type aphasia caused by damage to the supramarginal gyrus in the temporoparietal region where the stroke had happened (Aziz-Zadeh & Damasio, 2008). Hence, it was likely that he was suffering from conduction aphasia.

P1 had a higher ability to repeat Persian words than English words. Whenever he was asked to repeat English words, he would utter its Persian translation instead. For instance, when he was asked to repeat the word *dog*, he would readily say /sag/ instead of the English word. No matter how many cues and what types of cues were provided to him to repeat the word *dog*, he would still provide the Persian translation.

On the other hand, P2's speech was not fluent, and he exhibited a high level of alexia. Moreover, because of a right-sided hemiparesis, he could not write. During the treatment, he did not show any pathological language switching or mixing. Instead, the normal patterns of bilingual code-switching were observable in the way he used the two languages. When we were speaking to the participant in English, he would try to speak in English, and when he could not retrieve suitable English words, he would switch to Persian. Moreover, the site of lesion reported by him was not in line with the regions usually related to pathological language mixing (Fabbro, Skrap, & Aglioti, 2000).

Both participants indicated difficulties in naming in both languages concerning the results from the naming section of BAT and BNT. Whereas the BNT score for P1 was almost twice his score on WAB, both scores showed that he was in the severely anomic category. Moreover, P2's scores for Persian were higher than English, potentially confirming his prestroke dominance of Persian.

3.3. Diagnosis of Spoken Naming Deficits

According to the models discussed in Introduction section, both languages are assumed to be of a common semantic or conceptual system. This assumption requires treatment aimed at impaired semantics to evoke a few cross-language gains because the strengthening of semantic representations is required to simplify the coactivation of lexical representation in both languages among bilinguals with different pre and postmorbid proficiencies through their common semantic characteristics.

The primary objective was quantifying participants' naming disorder in English versus Persian and assessing the effects of word length and frequency. Many stimuli were extracted from the WAB (Kertesz, 1982). Ninety-eight items were selected from Lists A and B in the object and action naming battery for naming in English, and a set of 40 items was developed for Persian naming (some of which were obtained from Nilipour, 2012, and some others were derived from tests at the Shahid Beheshti University of Medical Sciences). Nine cognates were included in the English list, among which two cognates were correctly named. The Persian list had no cognates. The lists were classified based on length and frequency, as shown in Table 1. The groups of the high-frequency cognates (i.e., English M = 207.6 and Persian M = 293.8), the low-frequency cognates (i.e., English M = 11.5 and Persian M = 15.7), the short cognates (i.e., English M = 4.4 and Persian 4.6), the long cognates (i.e., English M = 6.8 and Persian M = 6.4) and the sets were matched by analyzing the correct responses to high-frequency words versus low-frequency ones and short words versus long ones:

Table 1. *Performance on Picture Naming Assessment*

Object and Action Naming (in English)				Object and Action Naming (in Persian)		
	Repetition (%)	Correct (%)	Correct (*N*)	Repetition (%)	Correct (%)	Correct (*N*)
Low Frequency	94	35	15	100	20	3
High Frequency	97	69	33	100	30	5
Short Words	97	54	26	100	25	4
Long Words	92	40	11	100	25	4

3.4. Accuracy of Naming

The following four figures (Figures 2-5) represent the results related to the correct answers for the two participants in the treatment and probe sessions. A time series analysis was performed to evaluate the effectiveness of intervention using the C statistic. A two-tailed test was used to determine the p value.

3.4.1. Participant 1

The first participant attended 16 intervention sessions together with nine trial sessions. However, after the ninth testing session, he stopped participating in the study:

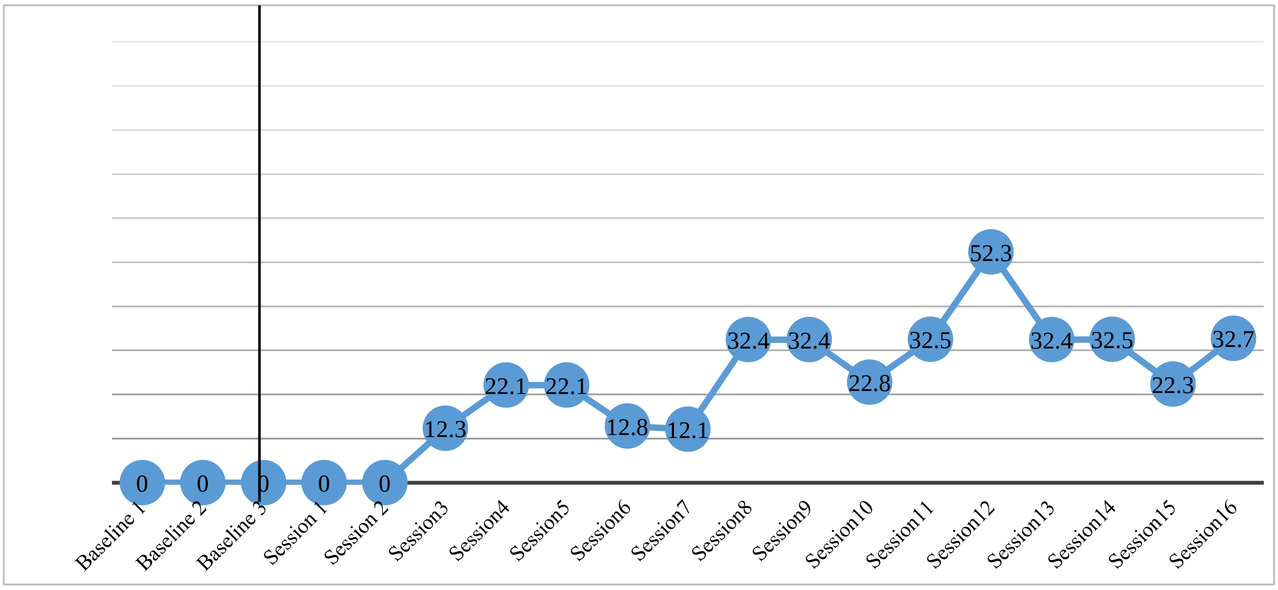

Figure 2. P1-Graphs of Percent Correct Naming Accuracy During Treatment Sessions

Although the first participant showed significant improvements during the intervention (i.e., the accuracy of 0-50%, $C = 0.733,\ z = 4.56,\ and\ p = 0.039$), the same levels of improvement were not observed in the trial sessions (i.e., the accuracy of 0-40%, $C = 0.538, z = 2.28,$ and $p = 0.375$). The fact that this participant could reach an accuracy of 40% in the last treatment session could not be explained because his performance in previous trial sessions had an accuracy range of 0-20% (see Figures 2-3). Unfortunately, it is not possible to ascertain whether he could reach higher levels of accuracy if he continued participation in the intervention. Moreover, for this participant, no generalization was observed to semantically related words or the translations of trained and untrained semantically related words:

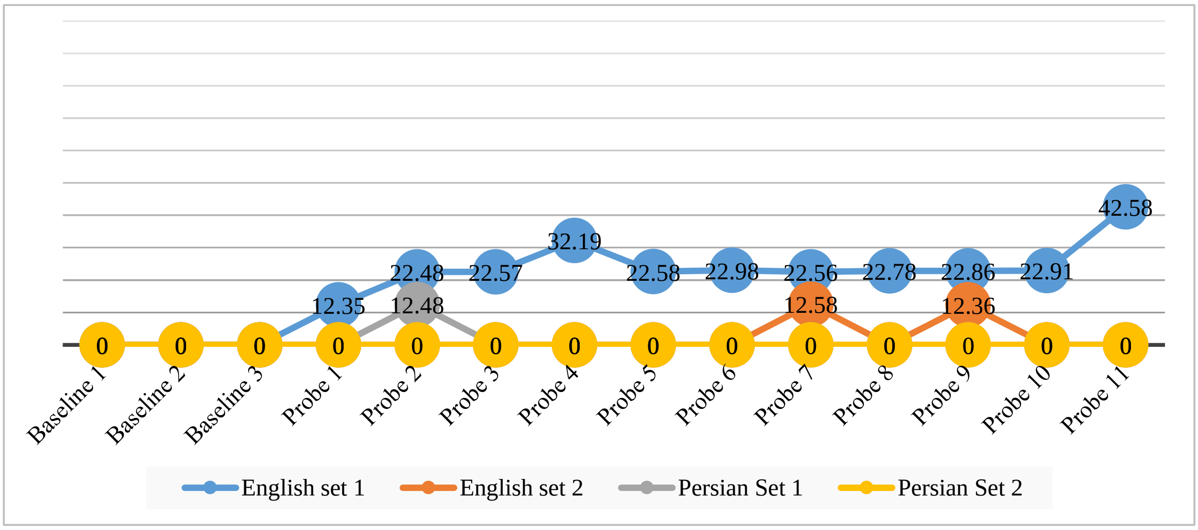

Figure 3. P1's Treatment Probes

3.4.2. Participant 2

The second participant took a 6-week follow-up test. This test showed that his performance was higher than baseline levels for trained English, untrained semantically related English, and Persian synonyms of untrained semantically related words. However, these results could not be considered statistically significant. The follow-up test also showed improved performance in English and Persian control items (see Figures 4-5):

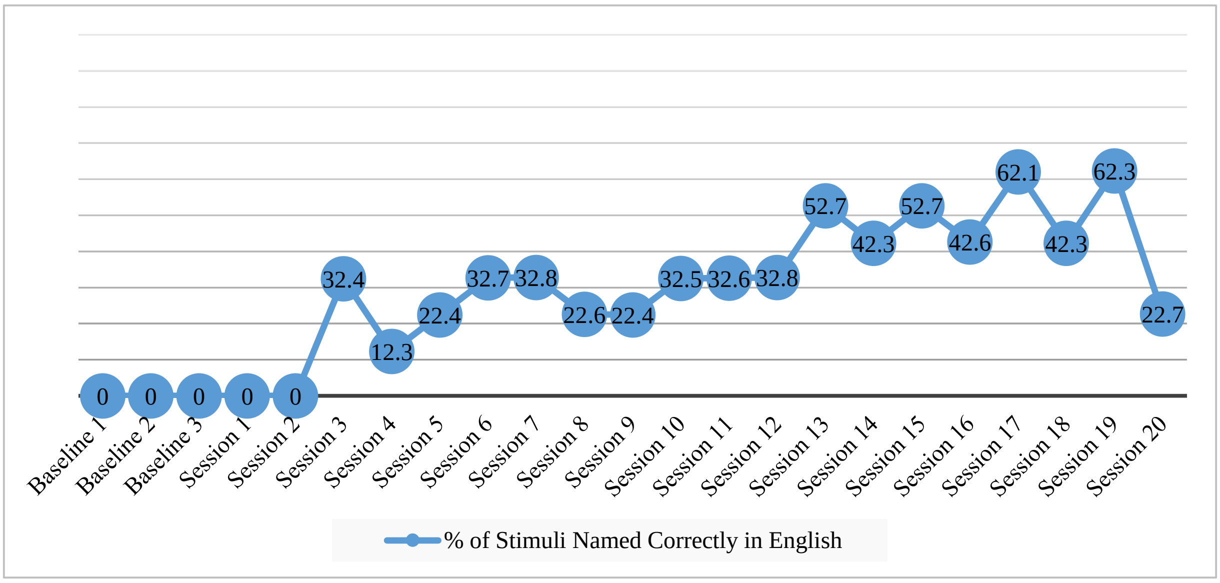

Figure 4. P2-Graphs of Percent Correct Naming Accuracy During Treatment Sessions

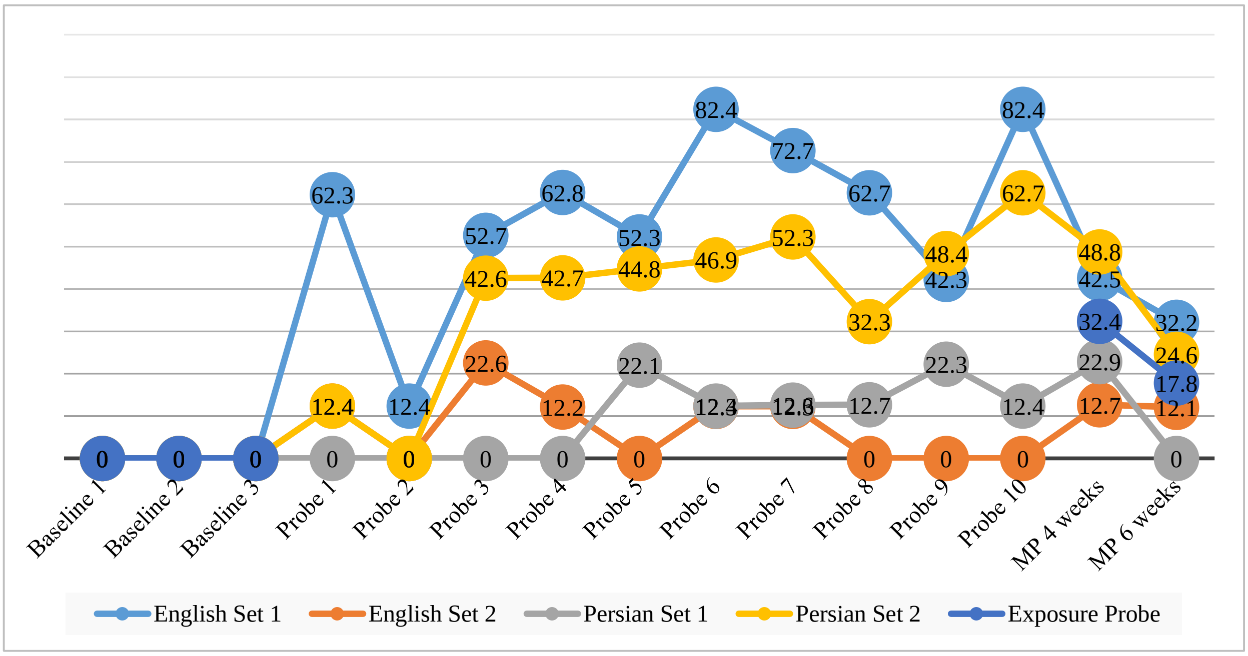

Figure 5. P2's Treatment Probes

3.5. Pretest and Posttest Measurements

After the completion of the intervention, the two participants took the same language tests they had taken before the intervention. Figure 6 illustrates the naming accuracy of each assessment stage for different sets. The Persian translation and English treatment sets were separated into noncognates and cognates to represent their improvement differences.

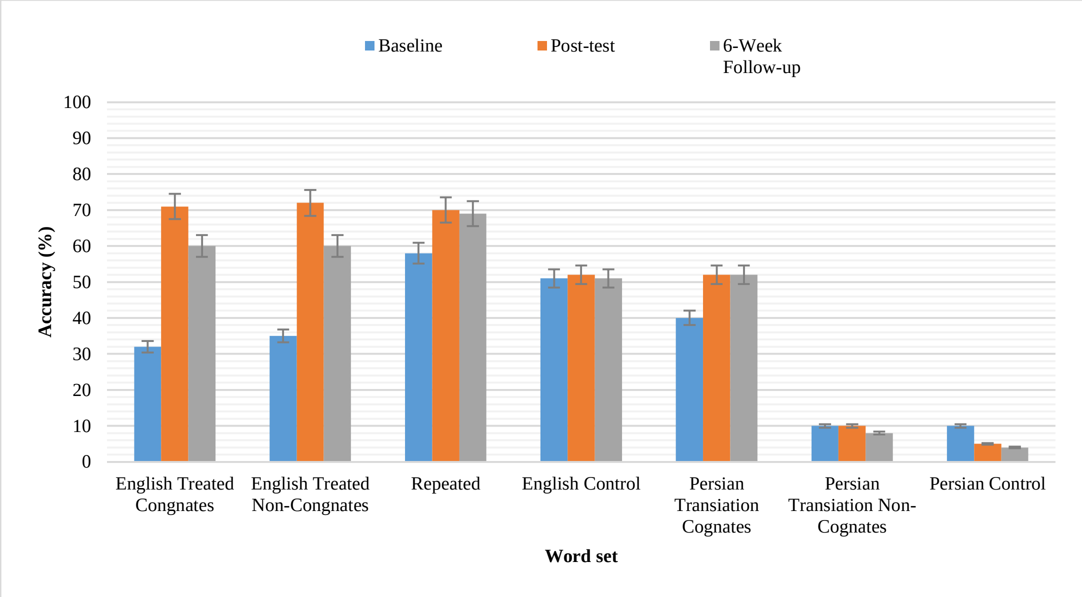

Figure 6. Naming Accuracy of Each Assessment Stage for Different Lexical Sets

Table 2 compares the extent of changes in the correct responses between the posttest and baseline tests and between the 16-week follow-up and baseline tests:

Table 2. *Changes in Correct Responses Between Posttest and Baseline Tests and Between 16-Week Follow-Up and Baseline Tests*

	Baseline (*x*3)	Posttest (*x*3)	Follow-Up (*x*2)	Baseline-Posttest Improvement (%)	Follow-Up (%)
English Treated Cognates	12/50	27/50	15/37	37.6	27.3
English Treated Noncognates	13/50	27/50	15/37	35.1	24.5
English Repeated	45/89	54/89	35/63	10.6	9.4
English Control	38/86	39/86	25/61	0.4	5.1
Persian Translation Cognates	15/50	20/50	13/37	11.9	11.9
Persian Translation Noncognates	3/50	3/50	1/37	0.0	-1.7
Persian Control	8/89	4/89	2/63	-4.2	-4.9

Table 3 compares the language improvements of the posttest and the baseline tests in each treatment phase for both P1 and P2. Figure 7 represents the improvement progression of assessment sessions from the baseline test to the posttest and follow-up for P1 during the treatment phases of English and Persian, respectively:

Table 3. *In-Language Improvements for P1 and P2*

	Complete Lexical Items				Partial Lexical Items			
Set	*N* (2 administrations)	Baseline	Posttest	Improvement (%)	*N* (2 administrations)	Baseline	Posttest	Improvement (%)
Participant 1								
Phase 1: Treatment of English Lexical Items								
English Treated	50	9	24	+33%	375	289	336	19.00
English Repeated (Untreated)	44	8	10	+7%	341	277	271.6	-3.28
English Control	46	12	9	-5 %	349	284	281.6	-1.14

Phase 2:								
Treatment of Persian Lexical Items								
Persian Treated	50	8	27	+42 %	347	272	207.6	16.36
Persian Repeated (Untreated)	50	11	16	+10 %	351	271	285	7.08
Persian Control	50	10	9	-1 %	349	272	282.6	5.35
Participant 2								
Phase 1:								
Treatment of English Lexical Items								
English Treated	74	22	72	+73%	631	470	627	30.39
English Repeated (Untreated)	74	17	62	+65 %	615	481	502	26.12
English Control	74	21	37	+24 %	621	407	556	11.05
Phase 2:								
Treatment of Persian Lexical Items								
Persian Treated	74	23	61	+55 %	657	535	630.6	21.52
Persian Repeated (Untreated)	74	31	44	+20%	631	567	587	5.96
Persian Control	74	19	34	+23 %	619	529	558.6	5.75

Figure 8 represents the same findings for P2 (bar the follow-up in the second phase). As seen, the maximum scores 53 and 98 belong to P1 and P2 (some of the sets had slightly fewer items because of removed duplicates), respectively.

In the first phase, P1 improved by 31% for treated items between the baseline test and posttest (McNemar test, $p < .0001$). However, no significant improvement was observed in the repeated untreated sets (McNemar test, $p = 0.84$) or the language control sets (McNemar test, $p = .086$) for CWS. This effect was evident at the 16-week follow-up (i.e., McNemar tests, $p < .001$, $p > .99$, and $p = .885$ for the treated, repeated, and control sets, respectively).

There was a comparable pattern within the second phase. The treated words exhibited significant improvement of about 40% (i.e., McNemar test, $p < .001$). Moreover, the improvement trend was insignificant within the repeated set (McNemar test, $p = .09$ (one-tailed)). The language control set did not show improvement (McNemar test, $p = .99$). The improvement pattern of a significant rise in the treated items maintained only at the 16-week follow-up (McNemar tests, $p = .005$, $p > .99$, and $p = .799$ for the treated, repeated, and control sets, respectively):

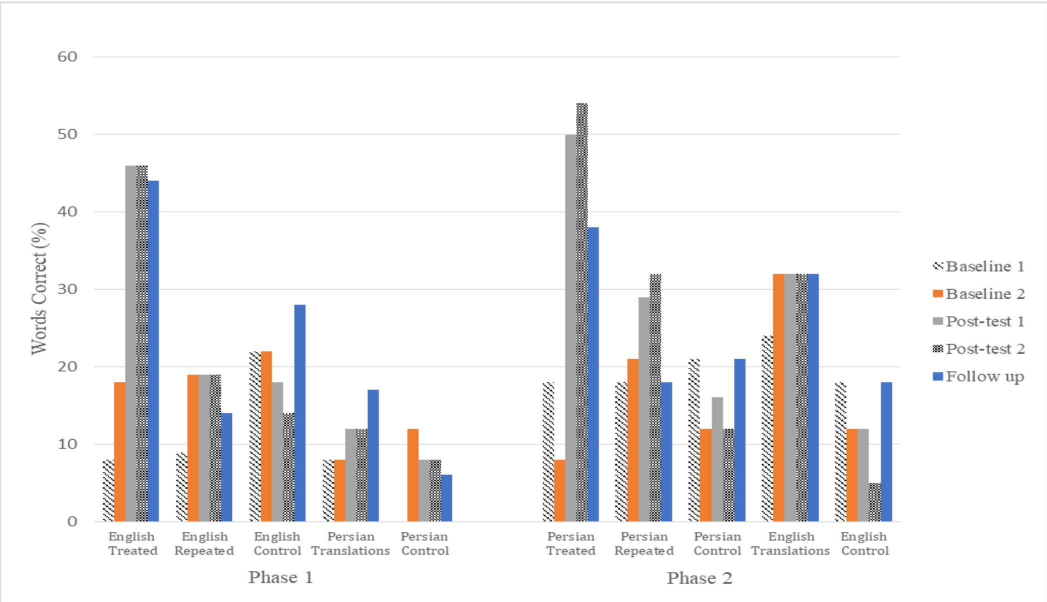

Figure 7. P1's Full-Length Lexical Naming Accuracy Across Phases 1 and 2 Trials

Figure 8 shows P2's progress in the Persian and English treatment phases. Both phases exhibited similar improvement patterns (see Table 4). The English treated, repeated, and control sets revealed significant improvements of 69% (McNemar test, $p < .001$), 65% (McNemar test, $p < .001$), and 22% (McNemar test, $p = .003$), respectively, between the baseline test and the posttest. Also, improvement continued at the 16-week follow-up (i.e., McNemar test $p < .001$, $p < .001$, and $p = .046$ for the treated, repeated, and control sets).

The second phase showed similar improvement patterns. The all cross-language treated, repeated, and control sets improved significantly. The Persian treated, repeated, and control sets improved by 53%, 18%, and 21% (McNemar test, $p < .001$, $p = .01$, and $p < .001$) between the baseline test and the posttest, respectively. However, there were no follow-up data because P2 could not proceed beyond the posttest:

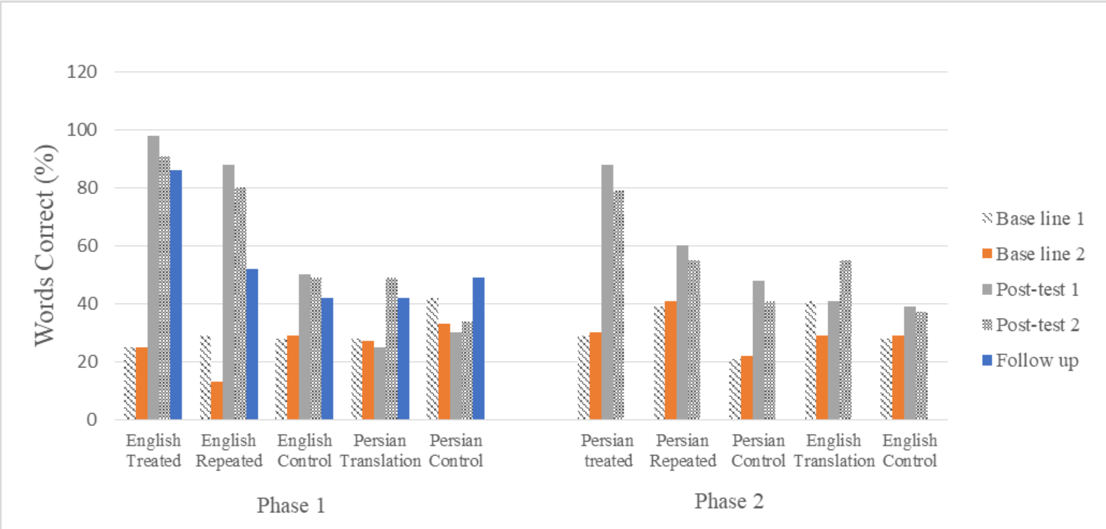

Figure 8. P2's Full-Length Lexical Naming Accuracy Across Phases 1 and 2 Trials

Table 4 compares the language improvements of P1 and P2 in the first and second phases. In the first phase, P1 exhibited no significant improvements in the Persian sets (i.e., McNemar test, $p = .74$ and $p =. 99$ for the translation, and control sets, respectively). At the 16-week follow-up, no changes occurred within the cross-language sets (i.e., McNemar test $p = .219$ and $p < .99$ for the Persian translation, and control sets, respectively).

In the first phase, P2 did not show significant changes between the baseline test and posttest for untreated translation and control sets (i.e., McNemar test, $p = .63$, and $p =.71$), respectively. They maintained at the 16-week follow-up for translation and control sets, respectively (i.e., McNemar test, $p = .945$, and $p = .516$):

Table 4. *Cross-Language Improvements for P1 and P2*

Set	Complete Lexical Items				Partial Lexical Items			
	N (2 administrations)	Baseline	Posttest	(%) improvement	*N* (2 administrations)	Baseline	Posttest	(%) Improvement
Participant 1								
Phase 1:								
Treatment of English Lexical Items								
Persian Translations of English Treated	50	6	8	+6 %	359	264	275	5.56
Persian Unrelated Control	50	5	6	+4 %	365	261	275	6.62
Phase 2:								
Treatment of Persian Lexical Items								
English Translations of Persian Treated	50	16	16	+0 %	343	287	281	-2.48
English Unrelated Control	50	19	4	-8 %	377	286	287	0.42

Participant 2								
Phase 1:								
Treatment of English Lexical Items								
Persian Translations of English Treated	74	27	31	+8 %	632	518.0	546.5	6.68
Persian Unrelated Control	74	29	32	+6 %	631	544.0	552.0	2.68
Phase 2								
Treatment of Persian Lexical Items								
English Translations of Persian Treated	74	27	37	+16 %	675	570.0	611.5	6.65
English Unrelated Control	74	21	28	+12 %	667	573.0	579.5	2.37

However, P2 exhibited a significant improvement in the Persian treated set translated into English (McNemar test, p=.043, one-tailed). Also, an improvement trend was evident in the cross-language controls (i.e., a 10% rise in the number of correct responses, McNemar test, p=.211 [one-tailed]). There was no data on the 16-week follow-up because P2 could not proceed beyond the posttest of the second phase.

3.6. English Results

As expected, P1 with a higher level of pre and postmorbid L1-L2 proficiency showed a significant improvement in the treated words. An improvement of 39.15% was observed for the English treated cognates, from a correctness rate of 35.23% in the baseline test to a correctness rate of 69.94% in the posttest (McNemar test $p < .001$). Also, there were still evident effects in the 16-week follow-up, with a correctness rate of 63.25% (McNemar test $p = .028$). An improvement of 37.1% was found for the English treated noncognates, with a mean correctness rate of 36.2% in the baseline test and a mean correctness rate of 73.80% in the posttest (McNemar test, $p < .001$). In addition, an improvement of 63.45% was achieved in the follow-up (McNemar test, $p = .021$). Hence, both English treated noncognates and cognates exhibited improvement patterns of high comparability. Such effects were found to be significant at the 16-week follow-up, although an insignificant reduction occurred between the follow-up and the posttest (McNemar tests, $p = .15$, and $p = .51$ for the cognates and the noncognates). The attempted untreated English words improved significantly (McNemar test, $p = .01$). However, these improvements were smaller than the treated words, with the correctness rates of 59.28%, 72.16%, and 71.05% in the baseline test, the posttest, and the follow-up, respectively). Such words had a higher level of performance in the baseline test, although, according to the significant results, there was potential for improvement. Performances on untreated control words not presented during the treatment phase did not improve (McNemar test, p = n.s).

3.7. Persian Results

As expected, the Persian translation cognates exhibited significant improvements (McNemar's test, $p = .034$, one-tailed). The correctness rate of Persian cognate naming improved from 41.03% in the baseline test to 55.70% in the posttest and the same level of effect maintained in the 16-week follow-up. The overlap of cognate pairs was analyzed with no significant effect on the overlap position. The noncognate translations of English treated items showed no changes. The Persian control set declined insignificantly between the baseline test and the posttest (McNemar test, $p = .22$), with a further decline in the follow-up (McNemar test, $p = .34$). The naming accuracy of all sets remained stable between the posttest and the 16-week follow-up (i.e., no significant difference between the 16-week follow-up and the posttest, all McNemar tests, p = n.s). This implies that the treatment had lasting effects on the phonological output lexicon.

3.8. In-Language Improvements

The treated items experienced significant improvement after the treatment (i.e., the generalization to various pictures). It can be said that the treatment contributed to the reactivation of the treated words' lexical representations, which is consistent with earlier improvement findings on treated items after phonological treatment protocols among both bilinguals and monolinguals (e.g., Edmonds & Kiran, 2006; Fisher, Wilshire, & Ponsford, 2009). The repeatedly attempted, yet insignificantly treated items of P1, experienced significant improvement in each session, which is consistent with earlier results making repeated attempts improve production (e.g. Rapp, 2005). Thus, it can be suggested that repeatedly attempted items can help activate damaged representations. The accuracy fluctuations in the baseline test measurements support the previous claims that fluctuating items in the baseline test are more likely to respond appropriately to repeated tests than stable ones (McKissock & Ward, 2007). Neither untrained English nor Persian items improved with no association with the treated ones (i.e., Persian and English control sets). This supports the claim that the strengthening of damaged lexical representations would improve words with explicit exposure to repeated testing or treatment rather than untreated unrelated items (Rapp & Kane, 2002).

3.9. Cross-Language Improvements

Due to the output lexicon diagnosis, P1 was assumed to be more likely to exhibit cross-language generalization to Persian cognates than Persian noncognates, considering the phonological nature of treatment and the structural similarity of cognates and noncognates. The assumption was grounded on models that assumed greater coactivation between words of the same form and meaning in the two languages due to extra phonological feedback activation (over noncognates; Costa, Caramazza, & Sebastian-Galles, 2000). The Persian translation set was improved but only for cognate stimuli. Therefore, the treatment was proposed to contribute to cognates through phonological feedback alongside the semantic connections. This supports the reports by Kohnert (2004), demonstrating cross-linguistic generalization in Spanish-to-English bilinguals but only among cognate stimuli.

Because there were no significant differences between the noncognate translations, the treatment could be said to have functioned at the output lexicon level. If the treatment had affected semantics rather than lexical representations, the noncognate translations would have improved concerning their meanings rather than similarities. The translation mistakes of the Persian noncognate items increased, which might have arisen from better naming tasks in English compared to Persian. However, it could have also been a therapeutic by-product of the treatment; the participant might have been accustomed to English naming. Also, the participant was aware that certain words within the Persian translation set seemed to resemble the English words. This might have induced confusion in the naming attempt of the noncognate translations.

Many translation mistakes in the Persian naming and the greater accuracy in the English naming imply that P1 had a nonparallel recovery of the spoken naming, which can make suggestions for models of bilingual lexical access. P1 seemed to have primarily processed single items in English. Such a nonparallel recovery agrees with models proposing two lexicons for bilinguals (e.g., Kroll & Stewart, 1994; Potter, So, von Eckardt & Feldman, 1984). It also challenges their assumptions; despite their high English and Persian proficiency, P1 reported Persian as his first and premorbid stronger language in spoken production. Based on the assumptions of such models, Persian (i.e., L1) should be of higher damage resilience than English (i.e., L2). Also, P1 had an inconsistent recovery pattern with the claim that the native language should undergo a greater level of recovery (Paradis, 2004; Ribot, 1881) and the argument that the most premorbid-used language should experience greater recovery (Paradis, 2004).

3.10. Interacting Variables and Caveats

One of the issues with conducting bilingual aphasia studies involves the fact that there is no single standard version of aphasia in the real world. Therefore, because aphasia patients do not constitute a homogeneous group, aphasia research cannot be applied in the same way to every aphasia patient. Accordingly, Lapointe (1985) believes that the effects of some of the interacting variables on aphasia recovery and treatment show that the study of this area is always highly complex and full of various risks.

Although numerous variables and their interactions may have affected the performance of the participants, language-related variables are most important regarding generalization, whether cross-linguistic or within-language. The participants were not only suffering from aphasia and the commonly concurrent anomia, but they were also suffering from some levels of alexia and verbal apraxia. Therefore, some parts of the intervention were related to the reading tasks that had to be adjusted to account for the alexia. Because none of the participants showed a consistent capability to read the stimulus items or cards related to the semantic feature, these instruments could not be used as indicators to help the participants during the intervention.

There is also the possibility of an adverse contribution from apraxia to intervention outcomes, preventing the participants from correctly naming some of the stimulus items. Whereas in cases where it could be determined that the participants knew the correct name of an item but could only provide a distorted response, that response would be accepted anyway. In some other cases, the participants were not even able to provide approximations of the correct answer, although they did their best. This harmed their performance concerning the naming items. This issue can act as a hurdle for determining whether it is related to the ability to name or problems with motor planning. Given that apraxia is often not accompanied by poststroke aphasia, this variable is an important factor that needs to be considered when developing research or therapy procedures for monolingual or bilingual people.

Probably, one of the most prominent issues related to the poststroke communication ability of the first participant involved his pathological language mixing and the fact that he was unable to control his ability to translate items from one language to items in the other language. The activation, control, and resource (ACR) model developed by Green (1986) captures difficulties with retrieving words and the issue of language mixing in bilingual aphasia. Based on the model, the lexical node must be excited for specific words, whereas the translation equivalents must be suppressed so that the person can perform the naming task (described in Ansaldo, Saidi, & Ruiz, 2010). The suppression of translation equivalents is carried out through two inhibitory mechanisms. These mechanisms include an internal and external inhibitory process: The internal mechanism enables a person to translate a lexical item from one language to another language, whereas the external mechanism enables a person to utter the lexical item in a specific language.

Therefore, if these mechanisms are, somehow, interrupted, the ability of a bilingual person to control access and production of lexical items in either language will be adversely affected. This will lead to pathological language mixing. Fabbro et al. (2000) showed that pathological language switching and mixing are related to lesions in the left temporoparietal lobe. Damage to the right hemisphere of the brain will affect the ability to retrieve words and perform semantic processing in bilingual people (Juncos-Rabadán, 2015; Paradis, 2004; Paradis & Libben, 2014). These findings are consistent with the fact that the first participant had a stroke in the right and left hemispheres of his brain. That is probably why he showed language mixing behaviors. His lack of ability to benefit from cross-linguistic generalization may be due to the damage to the neural connections between his two languages and the interruption of the inhibitory mechanisms that provide the ability to control languages in bilinguals.

On the other hand, the symptoms of P2 were more consistent with the usual symptoms of Broca’s aphasia (Fromkin, Rodman, & Hyams, 2018). His normal code-switching ability appeared through his ease in moving from one language to the next. Therefore, another explanation is essential for his lack of significant cross-linguistic generalization. As noted earlier, he had different levels of performance in various trial sessions, and his physical health problems during the study affected his performance. Therefore, there is a strong possibility that a greater number of therapy sessions could have stabilized his performance and levels of generalization.

However, a striking outcome of trial sessions for P2 was the fact that he had significant improvement in cross-linguistic generalization to the translation equivalents of untrained semantically related words, compared to his within-language and cross-linguistic generalization to trained words. He showed improved performance for trained English words and untrained semantically related Persian words. In this regard, available theories explaining word retrieval in the bilingual brain may be applicable for explaining these outcomes. For instance, Costa and Caramazza (1999) argue that, after observing a semantic representation of a lexical item, such as an image, the lexical item, is activated in both lexicons, whereas the words semantically related to the initial lexical item are also activated in both lexicons. On the other hand, the ACR model argues that after these activations, the person would inhibit the phonological representation of a lexical item in one language to utter the lexical item in the other language. If the bilingual person is more proficient in one language compared to the other, the process of lexical item inhibition in the former will result in a greater level of switch cost compared to the process of lexical item inhibition in the latter (Costa & Santesteban, 2004; Olson, 2016).

It is difficult to inhibit a lexical item in the dominant language compared to inhibiting lexical items in the nondominant language. It is worth mentioning that because of decreased neurological resources caused by lesions, this switch cost might be even higher in bilingual aphasia patients. Accordingly, during the intervention, p2 used significant neurological resources to inhibit the trained Persian words, whereas the semantically related words remained active in his brain. Therefore, he probably did this out of habit due to the number of resources devoted to inhibiting the trained Persian words during the intervention when it came to the testing phase. Meanwhile, the semantically related words would still be activated, and producing those words in Persian require far fewer neurological resources.

4. Conclusion

In the current study, two Persian-English bilingual stroke-induced aphasic patients were examined to explore the role played by pre and postmorbid language proficiency in cross-language generalizations. This was done by examining the languages they spoke with lower and higher proficiency levels after the intervention. Based on psychological and linguistic perceptions of bilingual representation and processing in this study, it is predicted that intervention for a language with a higher proficiency level can lead to cross-language generalization between languages with a similar level of proficiency by causing higher coactivation for languages with a similarly high proficiency level, compared to languages with different levels of proficiency. The results of nonselective activation of language for bilingual people, who are significantly proficient, are in line with this prediction.

Moreover, coactivation of languages can lead to cross-language generalization of the intervention for languages with a higher proficiency level while also resulting in cross-language intrusions for languages with a lower level of proficiency. In other words, a higher activation of languages with more proficiency can lead to the intrusion of words from highly active languages into languages with a lower level of activation. Although intrusion errors may be considered a behavior related to the aphasia condition, code-mixing (i.e., switching languages in the same sentence) or code-switching (i.e., switching language between sentences) are common phenomena seen in bilingual individuals. Producing target words in nontarget language is often typical between linguistically similar languages. However, code-switching between bilingual people with aphasia has been considered as an indicator of language problems, as well as a method of improving communication. In several studies, switching, or translation, is seen as a treatment strategy for an individual to retrieve words to translate equivalents better. On the contrary, switching languages may interrupt or inhibit communication when it is not intended or when the other person cannot speak the patient's language. Therefore, among bilingual patients with aphasia, reducing the level of unintended mixing and switching of language can be an indicator of success in language production.

All in all, the results cannot be generalized to other bilingual anomic aphasic patients because each case of aphasia is unique, and multiple interrelated and complex variables might affect the lexical recovery prognosis in these patients. Therefore, there is a need for further research in this area and clinical linguists and language interventionists working with bilingual aphasia patients need to perform comprehensive and detailed tests to determine the pre and postmorbid language abilities of patients. These practitioners need to design interventions compatible with the needs and linguistic characteristics of each patient.

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