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Cross-linguistic Generalizations in the Verb-Production Treatment of Bilingual Aphasic Speakers

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Abstract

Objectives: This study investigates cross- linguistic generalizations in the verb-production therapy for one bilingual speaker with non-fluent aphasia.

Methods: Intensive sixty-hour treatment sessions over a period of 12 weeks was provided for an unbalanced bilingual speaker with mild to severe aphasia. A combination of semantically and phonologically cued verbs as well as communication-based treatment were administrated. The treatment was provided in the patient's L1. *The Bilingual Aphasia Test* and action-naming pictures from *The Newcastle University Aphasia Therapy Resources* were used for the pre-and-post-therapy assessments for both languages.

Results: A cross-language generalization was reported from L1 to L2. A significant generalization was found in one linguistic domain, i.e., semantics. A within-language generalization was found, i.e., the untrained verbs of L1 showed significant improvement. Nonetheless, inhibition of the semantic domain of the patient's L1 was reported. Providing treatment for the stronger language of a bilingual aphasic individual could lead to cross-language transfer to the untreated weaker language.

Conclusions: We suggest that the cross-language generalization is reported due to the structural overlap between the two languages.

Keywords: Aphasia, bilingualism, cross-language transfer, verb production, bilingual aphasia test, the Newcastle university aphasia therapy resources, communication-based treatment.

التعاميم البين لغوية في معالجة إنتاج الأفعال عند ثنائيي اللغة المصابين بالحبسة الكلامية

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ملخّص

الأهداف: البحث في ظاهرة التعاميم البين لغوية في معالجة إنتاج الأفعال لدى شخص ثنائي اللغة مصاب بالحبسة الكلامية.

المنهجية: وفرت الدراسة جلسات علاجية مكثفة بواقع ستين ساعة موزعة على اثني عشر أسبوعًا لمصابة ثنائية اللغة صنفت حالتها ما بين متوسطة إلى متقدمة؛ حيث خضعت لعلاج يقوم على التواصل من خلال استخدام متقاربة المعنى واللفظ. وقد اعتمد العلاج استخدام اللغة الأم للمصاب. وقد استُخدم لهذا الغرض اختبار الحبسة الكلامية لثنائيي اللغة وصور تتطلب تسمية الحدث الذي تعبر عنه؛ حيث أخذت من مصادر معالجة الحبسة الكلامية لجامعة نيوكاسل جرى تطبيقها لتقييم حالة المصاب في اللغتين قبل المعالجة وبعدها.

النتائج: أظهرت الدراسة وجود تعميم بين لغوي من اللغة الأم إلى اللغة الثانية. وكان هذا التعميم واضحًا جليًا في مجال لغوي واحد وهو المجال الدلالي. ووجد أيضًا تعميمًا داخل اللغة نفسها؛ حيث بينت الدراسة حسنًا ملحوظًا في الأفعال التي لم يجري التدريب عليها في اللغة الأم. إلا أن الدراسة أظهرت أيضا وخلافًا لما هو متوقع بحسب الدراسات السابقة تراجعًا في المجال الدلالي في اللغة الأم.

الخلاصة: إن إخضاع المصاب للعلاج في اللغة الأقوى وهي اللغة الأم في حالة هذا المصاب يمكن أن ينتج عنه نقل بين لغوي إلى اللغة الأضعف وهي اللغة الثانية في هذه الحالة. ويمكن أن يفسر هذا النقل البين لغوي الذي أظهرته الدراسة لوجود تداخل بين بعض التراكيب باللغتين.

الكلمات الدالة: الحبسة الكلامية، ثنائية اللغة، إنتاج الأفعال، النقل لبين لغوي، اختبار الحبسة الكلامية، المعالجة بالتواصل.

1. Introduction

When dealing with aphasic patients, most speech pathologists are faced with the conundrum of choosing the language through which they will provide treatment. Deciding to treat one language does not indicate that they do harm for other languages. Positive cross-linguistic therapy effects (i.e., transfer from the treated language to the untreated one) may occur. Abundant research works have been conducted to explore cross-linguistic transfer (CLT) in multilingual aphasia. However, they have shown equivocal results. Some studies have found language transfer from a treated L1 to an untreated L2 or from a treated (less dominant) L2 to an untreated L1. Nonetheless, other related studies have not succeeded in finding cross-language generalizations that draw on their subjects.

Several variables lead to the presence or absence of cross-linguistic transfer effects. One variable pertains to the linguistic distance of the spoken languages. The similarities between languages at the levels of syntax, morphology, phonology, vocabulary, and meaning may lead to language transfer (Ansaldo and Saidi, 2014). Dijkstra (2005) mentioned that working on cognates, i.e., words with similar meanings and form in both languages, facilitates CLT. For instance, stimulating the word "Jamal" in Arabic will help the retrieval of the word "Camel" in English because they have similar sounds and meanings. Another factor that affects the possibility of CLT is the proficiency of the speaker before and after the aphasia onset. Several studies showed that treatment in the weaker language benefits the untreated stronger one (Edmonds and Kiran, 2006). Other studies suggested that training the stronger language after the aphasia onset is beneficial to CLT (Goral, 2012; Miertsch et al., 2009). Furthermore, the specific domain targeted in the treatment, such as lexical retrieval vs. morphosyntactic structure, plays a crucial role in deciding whether cross-language generalizations could be obtained or not. Several studies concluded that treatments that target a certain lexical item or a specific syntactic structure led to a weaker generalization as compared to treatments that focus on underlying processes such as semantic feature analysis therapy (Kiran and Roberts 2010).

The current study explores the effect of *Newcastle University Aphasia Therapy Resources (NATR)* therapy (Morris, Webster, Withworth, and Howard, 2009) on the treated and untreated language of a bilingual speaker with Broca's Aphasia.

2. Related Studies

The importance of studies of aphasia resides in shaping our understanding of the relationship between language and the brain. There has been a surge of interest in studying multilingualism and aphasia because most modern societies are becoming multilingual. Multilingualism is a prevalent phenomenon (Ijalba, Obler, & Chengappa, 2013, Weir, 2000). It is even apparent that an increasing number of individuals are polyglots. In recent years, many studies have been conducted to investigate cross-linguistic transfer in therapy for multilingual aphasics. The need to conduct such studies is apparent as they help speech-language pathologists (SLPs) with their clinical protocol for bilingual patients. In addition, they guide SLPs to use the best practices for the assessment and treatment of aphasia. Research on cross-linguistic transfer assists SLPs in deciding whether to provide the treatment in the patient's L1, mother tongue, or L2, i.e., second language.

The findings of cross-language transfer studies are disputable. Some studies have found language transfer from a treated L1 to an untreated L2 or from a treated (less dominant) L2 to an untreated L1(Ansaldo and Saidi, 2014, Dijkstra 2005, Knoph et al. 2017). However, other studies have not succeeded in reporting CLT for their participants. Goral, Levy, and Kastl (2010) provided treatment for a trilingual Hebrew-English-French aphasiac who suffered from mild to chronic aphasia. They aimed to examine any cross-language generalization that can be resulted from treating the patient's second language. i.e., English. The two treatment blocks focused on morphosyntactic skills and the language production rate. The patient did not only demonstrate a slight improvement in both blocks in the treated language. i.e., English (L2), but also in French, which is his least dominant language (L3). After the first treatment block, the patient showed gains in accuracy rates in prepositions, pronoun-gender agreement, and tense consistency. These findings suggest that a cross-language generalization might be observed in shared components between different spoken languages (the treated and the non-treated ones). This is supported by the fact that no gains were reported in the French rates of Article-Noun agreement, which is a morphosyntactic component that exists only in French. No considerable increase in the patient's first language was found. The lack of improvements in Hebrew morphosyntactic accuracy and speech rates can be attributed to the ceiling performance in Hebrew, i.e., the high-

performance rate of the patient's mother tongue. Another factor that might lead to the absence of a cross-language generalization between the treated English and untreated Hebrew relates to the fact that there exist a differential representation and processing of the two languages because of the status of Hebrew as the patient's first language. On the contrary, there was a cross-language generalization between French and English as these two languages were not the patient's L1. Moreover, this can be viewed on the grounds that English and French have a shared origin (so English and French may have more shared structures and representations at the lexical level than English and Hebrew), as stated Goral et al. (2010).

The importance of lexical similarities in determining cross-language generalizations is illustrated in Kohnert's study (2004). The author studied generalization within and across different cognitive-linguistic domains. The author provided two treatments for a bilingual aphasic. The first treatment was a cognitive-based treatment that tackled non-linguistic skills, such as visual scanning, categorization, and simple arithmetic. The second treatment was a lexically-based treatment that tackled cognates, i.e., words that share similar meaning and form across languages, such as rosa/rose. The second treatment also examined non-cognates. i.e., words that have the same meaning but different forms, such as mesa/table. Modest gains in the two languages (Spanish and English) followed the first treatment. The second treatment generated an improvement in naming both non-cognates and cognates within each language. On the other hand, generalizations of gains were reported only for the cognate stimuli.

An investigation carried out by Croft, Marshal, Pring, and Hardwick (2011) has looked as the treatment of naming difficulties for five aphasic patients who were bilingual in English and Bengali. All of them suffered from word-finding difficulties in the two languages. Each participant received the therapy in Bengali and then in English. The researchers tested two groups of words with semantic and phonological tasks. The participants received a ten-hour therapy which was carried out twice a week. Each therapy session lasted one hour, namely half an hour for semantic treatment and the other half for phonological treatment. The first author carried out the therapy in English while a co-worker delivered the therapy in Bengali. The researchers measured the several effects of the treatment using a picture naming task including treated and untreated items(control). In addition to investigate any cross-language transfer that might result from the therapy, the researchers examined whether the naming therapy techniques created for monolinguals are sufficient for bilinguals. They also aimed to discover if the languages respond differently to language therapy. The researchers found that the typical naming therapy designed for monolinguals is beneficial for some bilingual individuals with aphasia. Most of the participants benefited from the semantic and phonological therapy, and the gains of the therapy happened in both languages, i.e., English and Bengali. On the other hand, one participant showed no significant benefit in either language. Furthermore, the researchers observed few instances of the CLT generalization. The direction of CLT was from L1to L2, i.e., from the stronger to the weaker language, and CLT only resulted from the semantic treatment.

The results mentioned above are in fact in contradiction to other studies. For example, Kiran and Roberts (2010) replicated the study of Edmonds and Kiran (2006) using a similar experimental design and methodology. They provided a semantic feature analysis treatment for four participants (Spanish/English speakers and French /English speakers) with anomic aphasia. The therapy focused on improvement of the naming of nouns in both languages of each patient. The researchers wanted to measure the within-language generalization and the cross-linguistic generalization. The researchers found that all the trained items in the trained language for three patients improved, a matter that highlights the efficacy of the Semantic Feature Analysis therapy. On the other hand, Kiran and Robert argued that one patient showed a slight improvement because of her severe aphasia. Furthermore, a within-language generalization occurred for three patients. For instance, improvements in the non-treated item *window* occurred after the treatment of the item *door*. Kiran and Roberts (2010) attributed this improvement to the fact that the two items are semantically related. Moreover, a cross-language generalization only occurred for semantically related items for two patients. The researchers argued that this finding could support the tentative explanation that the treatment in the weaker, less dominant language is more likely to facilitate a cross-language transfer of the untreated items than the treatment in the patient's dominant language.

The results of Kiran and Robert (2010) are discussed according to the mixed model of bilingual language distribution (de Groot, 1992) and by the Complexity Account of Treatment Efficacy (Thompson, et al., 2003). According to Groot's model, languages have a shared semantic system, but they have separate lexicons that directly access each other and the

semantic system. The strength of the connections between the separate lexicons and between the lexicon and the semantic system depends on the individuals' proficiency. Therefore, if a person is more proficient in Spanish than English, like Kiren and Robert's patient, the link between his less dominant language, i.e., English, and the semantic system, will be weaker than the link between English and Spanish lexicons. As a result, it would be more complex for him to speak English as he will not rely on the weak link between English and the semantic system. Rather, he will rely on the stronger link between the English the Spanish lexicons.

Knop (2013) studied the cross-linguistic effect of a therapy for verb production in a trilingual Arabic-English-German speaker with severe non-fluent aphasia. In recent years, more and more research studies are conducted to examine verb retrieval because it is more challenging than noun retrieval for monolingual and multilingual speakers with aphasia. Verbs are generally more complex than nouns. The treatment was provided in English (L2 of the patient and the pathologist). The study aimed to target the verb production in a complete sentence using the Newcastle University Aphasia Therapy Resources (NATR) (Morris, Webster, Withworth and Howard, 2009). A native-speaking interpreter assessed the participant with the Jordanian Arabic version of the BAT (Paradis and El Halees, 1989).

The authors themselves conducted the assessment of English using the English version of the BAT (Paradis, Libben and Hummel, 1987). The treatment was not intensive; it was provided three hours a week for 10 weeks. The therapy targeted the production of semantically and phonologically cued verbs, so the author selected 48 verbs from the NART. The participant had to see a card with an illustration of the action in question and his mission was to produce an appropriate verb within a simple sentence. The semantic cues included one noun and one verb that were semantically connected to the target word (e.g., if the target word was *drop*, the other verb could be *hold*, and the noun could be a *cup*). The cues of phonologically cued verbs were different; they consisted of the target verb's initial letter and a rhyming word (e.g., if the target verb was bake, the cues were b and rake). When the patient was able to name the actions and use them in a simple sentence, a more advanced communicative task was used, based on informative exchanges, i.e., a communication-based treatment of verbs which consisted of a different language - action games using the same 48 verbs. The results showed treatment-related generalization to the untreated language, yet not in all areas. The scores for the semantic domains improved significantly. This was explained as a direct treatment-related generalization. Because the treatment focused on complete sentences, the participant showed a slight improvement in his syntax scores. No improvements in the phonological tasks were found. Therefore, no cross-language transfer was found in this domain. There was no inhibition of the untreated language, i.e., Arabic. Moreover, the findings of the study showed that treatment provided in normal clinical settings in the less dominant language (L2) can lead to a cross-language generalization to L1. This could be so because of the shared conceptual system of the languages.

Knop, Linda, and Simosena (2015) used the Semantic Feature Analysis treatment to measure its effect on verbs instead of nouns. Knop and colleagues treated a quadrilingual speaker (Japanese-English-German-Norwegian) with non-fluent aphasia. The treatment was provided in his late acquired language, i.e., Norwegian. They offered intensive therapy with 29 sessions over 2.5 weeks. It is worth mentioning that a lot of previous studies have asserted the importance of intensive language therapy in aphasia rehabilitation (e.g., Bhogal, Teasell and Speechley,2003; Kelly et al.,2010). In fact, Mohr et al., (2017) have argued that intensive treatment reduces the symptoms of depression in chronic non-fluent aphasia. Following this treatment, there was a significant increase in the naming of trained verbs. A cross-language generalization at the lexical level and in syntax and semantics was evident in German (L3) and partially in English (L2). In addition, no improvements in Japanese (L1) were found. The authors stated that this could be the case because Japanese, among all the untreated languages, is structurally the most dissimilar language to the treated language i.e., Norwegian. Various studies (e.g., Goral et al., 2010; Faroqi-Shah et al.,2010) suggested that the similarities and differences across the languages play a crucial role in the cross-language transfer. They argue that CLT could be limited to the shared linguistic aspects which are common in the languages under investigation.

Other studies indicated the inhibition of one of the untreated languages of a multilingual aphasic. For example, Goral et al. (2013) conducted a study on a trilingual patient with non-fluent aphasia. The patients' most preserved language was her English, which she learned later in her life. Two treatment blocks were provided. The first was in English followed by

therapy in the patient's first language, Persian. The focus of the therapy was spoken language production. The treatment included principles from the constraint-induced aphasia treatment (CIAT).

CIAT is one of the constraint-induced therapies (CITs) in the field of rehabilitation. Zhang, et al. (2017) described CIT as "one of the most widely used strategies that aimed to avoid the "learned nonuse" in patients with stroke." He added that "it is also known as the "use-dependent learning" which includes high-intensity repetitive tasks delivered in a relatively short duration". There are three principles of CIAT:(1) constraints through which the patients are highly encouraged to avoid the use of compensatory strategies, like gestures or drawing; they are encouraged to communicate through verbal interaction instead. (2) mass practices, which indicate that the intensive protocol is provided for 2-4 hours per day for 10 days;(3) shaping, the degree of difficulty of the tasks increases gradually according to the individual's functional performance. The results showed that the English language improved after the English treatment block. Furthermore, the patients' performance in Persian improved following therapy in Persian. On the other hand, the patient performance in Persian was not generally affected by the treatment in English (poststroke stronger language). In contrast, the patients' performance in English was negatively affected after the therapy that targeted the Persian language as the grammatical accuracy of English decreased especially in structures that are different in the two languages including auxiliary verbs. Goral et al (2013) discussed their findings according to "the convergence hypothesis of bilingual representation (Abutalebi and Green, 2007) and psycholinguistics findings of asymmetric language inhibition." The convergence hypothesis is an alternative view to Paradis' view (2008). Paradis believed in the dissociability of the grammatical processing in L1 and L2. The grammatical knowledge of L1 and L2 dissociates because "L1 grammar is acquired implicitly through immersion whereas L2 grammar is learned explicitly through tuition." (Druks and Weekes, 2013)

The convergence hypothesis, however, states that the grammatical representations are shared. Druks and Weekes (2013) illustrate that "L2 grammatical proficiency increases via exposure in a dominant language environment, grammatical knowledge will converge onto thesame neural representations even for a bilingual speaker who acquires L2 relatively late in life." Therefore, Goral et al.(2013) argued that despite many variables such as language proficiency and language similarity, shared neuronal networks and simultaneous activation of multiple languages aid processing in any language, so cross-language treatment effects would likely be reported. The study reports that untreated languages benefit from therapy to one certain language is compatible with various studies (e.g., Edmonds and Kiran, 2006; Kohnert, 2004.) The patient performance showed a decrease in producing complete sentences. The patient also made more noun-verb agreement errors and more errors relating to auxiliary verbs in the English language. Goral et al. (2013) justified this decline as asymmetric language inhibition. When a bilingual person uses one of his languages, the other one needs to be inhibited. The stronger language has a strong activation, so inhibiting will occur to the stronger language than to the weaker one. Goral, Naghibolhosseini and Conner (2013) reported inhibition of the stronger language when providing language therapy to the weaker one. The current study aims at investigating the effect of the treated language on the untreated one after providing treatment of verb production of a bilingual speaker with aphasia.

3. Method

3.1. Case Details

DB, a pre-morbidly right-handed subject, participated in the study. She is a 30-year-old female patient who suffers from Broca's aphasia as a result of a stroke in the left hemisphere. She suffered no brain injury prior to the stroke and showed no signs of damage to the right hemisphere. She is a bilingual speaker (According to Weir (2000), a bilingual is a person who uses different languages for different purposes, in different contexts, with various degrees of proficiency to communicate with other interlocutors.); she speaks Jordanian Arabic as her first language (L1) and English as her second language (L2). She started learning English during her school years (from the age of four till 17). The patient then attended the American University of Beirut, where English was the medium of instruction. The participant had a medium level of proficiency in the English Language before the brain stroke. She reported that she used both languages daily prior to the stroke. However, she did not use English after the stroke.

Table 1: Demographics of the participant

Participant	Age	Gender	MPO	Aetiology	Aphasia Fluency
DB	30	F	86	CVA	Non-fluent

MPO: Months Post Onset/CVA: Cerebral Vascular Accident

Table 2: Summary of the patient's language history

	L1	L2
Language	Arabic	English
Age learned	Birth	Age 4
How learned	Acquired at home	Learned formally at kindergarten
Language use at the time of aphasia onset	The language of communication with family and friends	it was the medium of instruction and daily communication in her university
Proficiency	High	High
Language use at times of treatment	Frequently with family	Rarely
Language of treatment	Treated language	Non-treated language

The participant sustained a brain stroke when she was 21. Due to the brain stroke, DB suffered from right hemiplegia. The Bilingual Aphasia Battery (BAT, Paradis and Libben, 1987) showed that her English was the least recovered language, and that was in agreement with a self-report by the participant herself (despite the frequent use pre-onset). For a summary of DB's self-ratings of the languages, see Table 3. The participant received language therapy from a professional speech pathologist two years before the start of this study. The pathologist reported that the patient was not cooperative as she suffered from depression and general weakness and fatigue.

Table 3. Pre-stroke self-ratings of Arabic and English language competencies

Language	Speech	Reading	Writing
Arabic	Very good	Very good	Very good
English	Very good	Very good	Good

3.2. Treatment design and details

3.2.1. Treatment

The study adopted a single-subject pre-test–post-test (ABA) design (Pring, 2005). The treatment was provided in Jordanian Arabic, the participant's L1. It focused on the production of semantically and phonologically cued verbs. A communication-based treatment was provided, unlike drill-based exercises, it is designed to enhance the informative exchange between the SLT and the patient. The primary purpose of both treatments focused on producing verbs in complete sentences.

Treatment was conducted by a professional speech-language pathologist who is a native speaker of Jordanian Arabic. The intensity of the treatment was taken into consideration, so language therapy was provided 5 hours a week for 12 weeks. Sanjit et al. (2003) did comprehensive research of five electronic databases to evaluate the role of the intensity of language therapy in aphasia rehabilitation. They concluded that "The more intense the aphasia therapy, the better the outcome" (p.74). They also illustrated that studies that showed a significant treatment effect provided highly intensive therapy over a relatively short amount of time. Studies of lower intensity therapy over a long period of time did not result in significant improvements for patients with aphasia.

Since the therapy targeted verb production in complete sentences, we used pictures from *The Newcastle University Aphasia Therapy Resources (NATR)* (Morris, Webster, Withworth, and Howard, 2009). It is a set of resources that equipped the professional SLTs with three resource packs: auditory processing, sentence processing, and written comprehension. We used tasks from the Verb and sentence resources focusing on verb retrieval and sentence production. To add functional relevance to the treatment, we let the participant choose 80 verbs from a full list of 120. We divided the chosen verbs into

two groups: 40 semantically cued verbs and 40 phonologically cued verbs. During the therapy sessions, the SLT showed DB a card that includes a picture of a certain action. The participant's first task was to name the action. After completing the first task, the participant was asked to use the target verb in a simple sentence.

The semantic cues included a verb and a noun that were linked semantically to the target verb (e.g., if the verb was *bake*, the other verb could be *cook* and the noun could be cakes) see Figure(1). First, the participant was asked to produce the action orally. Second, she was asked to look at the semantic cues and then repeat the target verb three times. Finally, the SLT asked the participant to put the target verb in a simple sentence.

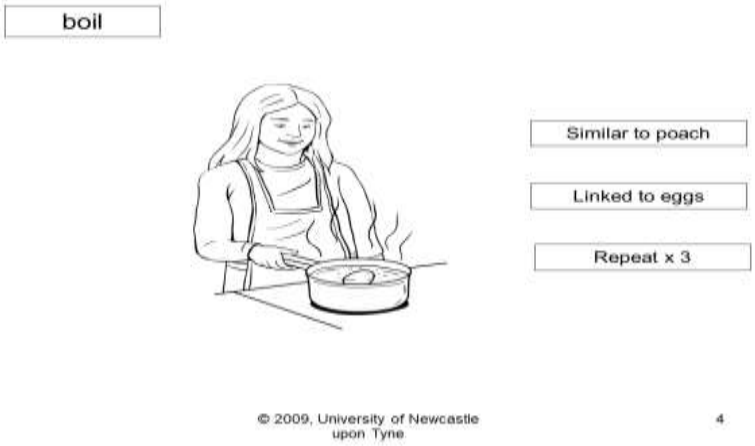

Figure 1. An example of semantically cued verb card from NATR Reprinted from The Newcastle University Aphasia Therapy Resources (NATR). Morris, Webster, Withworth, and Howards. In Tyne, Uo. N. U. (Ed.). The Newcastle University Aphasia Therapy Resources. Newcastle Upon Tyne: University of Newcastle Upon Tyne. Copyright 2009.

The initial letter of the target verb (or letters if it began with a consonant sequence) and a rhyming word represented the phonological cues of the target action(e.g., the letter *b* and the word *foil* were the phonological cues of *boil*) see Figure(2). The participant's task was to produce the verb orally, look at the phonological cues, repeat the target word three times, and then put it in a simple sentence.

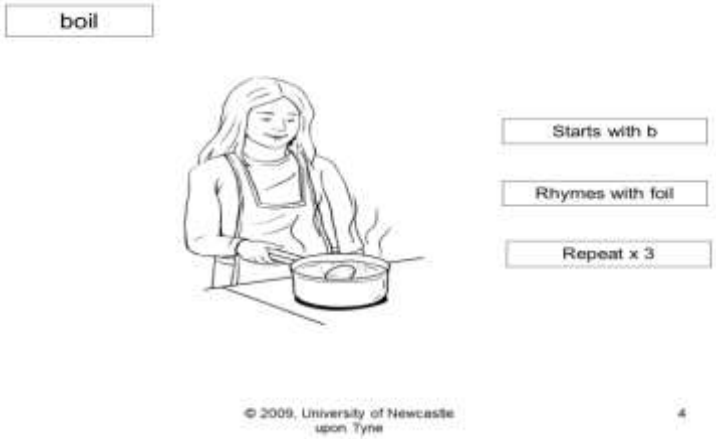

Figure 2. An example of phonologically cued verb card from NATR Reprinted from The Newcastle University Aphasia Therapy Resources (NATR). Morris, Webster, Withworth,and Howards. In Tyne, Uo. N. U. (Ed.). The Newcastle University Aphasia Therapy Resources. Newcastle Upon Tyne: University of Newcastle Upon Tyne. Copyright 2009.

Since the treatment was provided in Arabic, the participant's L1, an adapted version of NATR was used. the researchers of this study translated the NATR into Arabic. Out of 120 verbs in the original English list, we chose only 80 verbs because some verbs do not have an equivalent in Arabic, such as *juggle* and *march*. Other verbs were culture-specific like *preach*. The new pictures were hand-drawn by a professional artist. The researchers made sure that the artist's drawings were simple, with no full details, so they could be named easily. She also made sure that they elicit the intended verb, so the patient

would come up with possible descriptions. Moreover, the researchers tested the suitability of the new verb list by piloting a test in healthy population to make sure that they gave the desired answers which are accurate enough and fast enough.

Aphasia is traditionally treated based on repetition and drill-based activities. Recent treatment studies have illustrated that the use of communication-based treatment could be more effective in achieving positive results. In a comparison study between the two approaches, Kempler and Goral (2011) concluded that communication-based activities are more effective than drilling activities in improving narrative production in aphasia. Communication-based activities were used after few sessions (at this point, the patient was able to name all of the verbs spontaneously and produce a simple sentence). An example of a communication-based activity used to enhance the informative exchange between the SLT, and the patient was a picture description activity. Both the pathologist and the participant have an identical group of pictures that were arranged randomly. The participant's task was to select one picture and then describe it using a verb in the target sentence structure. The pathologist attempted to choose the picture that was described and then they exchange roles. Other interactive activities included Go Fish, Memory, and story construction.

3.2.2. Assessment

The researchers used the Jordanian Arabic version of the Bilingual Aphasia Test (Paradis and El Halees, 1989) to assess the participant's L1. English (L2) was assessed using the English version of the BAT (Paradis, Libben, and Hummel, 1987). The two languages were also assessed using pictures from The Newcastle University Aphasia Therapy Resources (NATR) (Morris, Webster, Withworth, and Howard, 2009).

To determine which language was best preserved after the stroke, pre-treatment assessments using the Bilingual Aphasia Test (BAT) (Paradis andLibben, 1987) were used to establish comparisons. Concerning the scores in comprehension subsets, the significance of McNemars test scored (p = 0.104), exceeding the significance level (0.05), reporting no significant differences in comprehension subsets for the two languages. Table (4) provided the results of Crosstabs for the assessments of comprehension subsets between AR-Pre and EN-Pre. See Figure (3).

Table (4): Crosstabs results for the assessments of comprehension subsets – AR-Pre vs. EN-Pre

AR_pre & EN_pre		
AR_pre	**EN_pre**	
	Wrong	**Right**
Wrong	33	25
Right	39	50

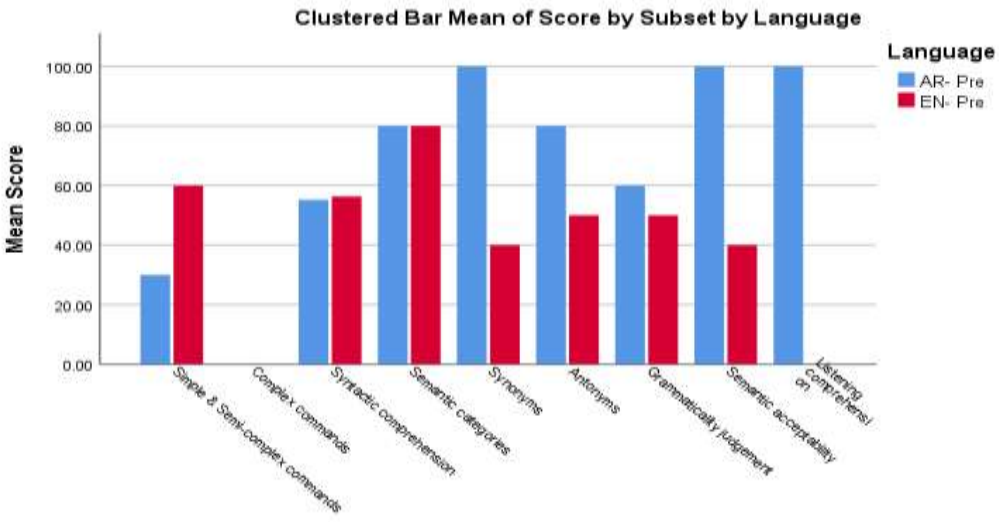

Figure (3): The cluster graph for the assessments of comprehension subsets between AR-Pre and EN-Pre

Pre-intervention scores of production subtests show significant differences between the two languages as McNemars test scored (p = 0.000) not exceeding the significance level (0.05). The results reported that AR was better than EN considering that scores in Naming, Semantic opposites, and repetition of sentences were higher in AR than EN; only the repetition of words subset scored approximately the same in the two languages. Table (5) provided the results of Crosstabs for the assessments of production subsets between AR-Pre and EN-Pre. See Figure (4).

Table (5): Crosstabs results for the assessments of production subsets – AR-Pre vs. EN-Pre

AR_pre & EN_pre		
AR_pre	**EN_pre**	
	Wrong	**Right**
Wrong	12	2
Right	27	26

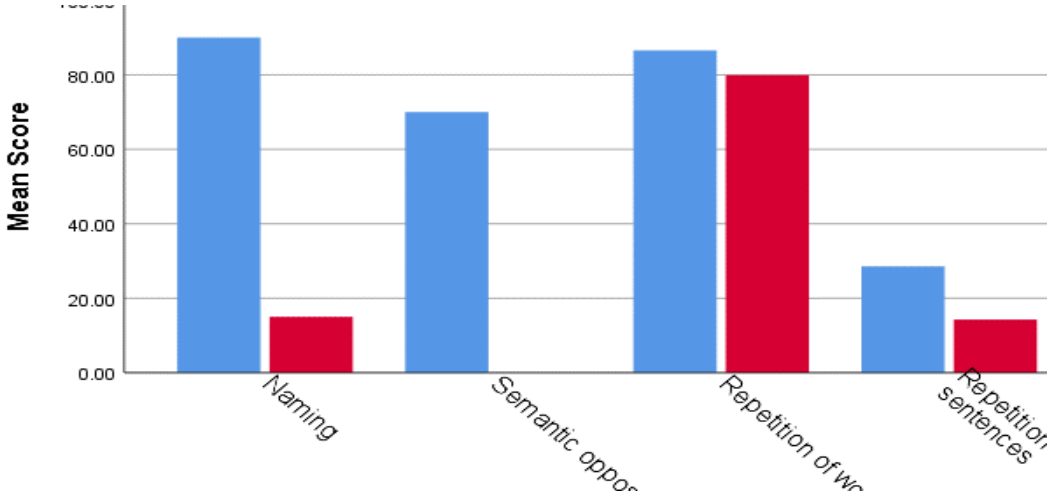

Figure (4): A cluster graph for the assessments of production subsets between AR-Pre and EN-Pre

4. Results

4.1 The results of the Bilingual Aphasia Test

BAT encompasses many subsets that can also be categorized at different linguistic levels (Paradis and Libben, 2014, p. 24). We provided comparisons at subsets and linguistic levels to provide a deep understanding of the extent to which treatments effectively achieved improvements in L1 (Arabic) and L2 (English).

4.1.1 Subsets level – general findings

Table (6) below provided the results of BAT in Arabic (L1) and English (L2) before and after treatments. Scores for each subset were established by assigning weight for each question. Weight was calculated by dividing [100/ (N) number of questions in the subset]; right answers were assigned the calculated weight. In contrast, wrong answers and non-responses were assigned zero weight.

Table (6) (inspired by Amberber (2011)) provided a closer look at the gains of all subsets in both Arabic (L1) and English (L2). Concerning Arabic language (L1), it was found that (14) subsets scored increasing, (9) scored decreasing and (9) scored no change. On the other hand, English language (L2) reported (15) subsets scored increasing, (6) scored decreasing, and (11) scored no change. The overall score for the two languages scored improvements.

Table (6): BAT results in Arabic (L1) and English (L2) pre-and post-treatment

No.	BAT subset	Arabic (L1)				English (L2)			
		Score		Result		Score		Result	
		N	Weight	Pre	Post	N	Weight	Pre	Post
1	Pointing	12	8.333	75.00%%	100.00%	10	10	60.00%	90.00%
2	Simple & semi-complex commands	10	10	30.00%	80.00%	10	10	60.00%	60.00%
3	Complex commands	5	20	00.00%	00.00%	5	20	00.00%	00.00%
4	Verbal auditory discrimination	18	5.55	77.70%	61.05%	18	5.55	27.75%	44.40%
5	Syntactic comprehension	87	1.15	55.20%	69.00%	87	1.15	56.35%	66.70%
6	Semantic categories	5	20	80.00%	80.00%	5	20	80.00%	60.00%
7	Synonyms	5	20	100.00%	0.00%	5	20	40.00%	100.00%
8	Antonyms	10	10	80.00%	60.00%	10	10	50.00%	40.00%
9	Grammaticality judgment	10	10	60.00%	80.00%	10	10	50.00%	40.00%
10	Semantic acceptability	10	10	100.00%	90.00%	10	10	40.00%	80.00%
11	Repetition—words	30	3.33	86.58%	93.24%	30	3.33	79.92%	86.58%
12	Lexical decision	30	3.33	69.93%	83.25%	30	3.33	96.57%	89.91%
13	Repetition—sentences	7	14.29	28.58%	28.58%	7	14.29	14.29%	14.29%
14	Series	3	33.33	00.00%	33.33%	3	33.33	00.00%	33.33%
15	Mental arithmetic	16	6.25	00.00%	00.00%	15	6.66	6.66%	00.00%
16	Verbal fluency	3	33.33	100.00%	33.33%	3	33.33	00.00%	66.66%
17	Verbal fluency (no. of words)*	//*	//*	3*	9*	//*	//*	1*	3*
18	Naming	20	5	90.00%	65.00%	20	5	15.00%	20.00%
19	Sentence construction	15	6.66	59.94%	66.60%	15	6.66	20.00%	20.00%
20	Sentence construction (no. of words)*	//*	//*	8*	12*	//*	//*	6*	5*
21	Semantic opposites	10	10	70.00%	30.00%	10	10	00.00%	20.00%
22	Derivational morphology	10	10	40.00%	20.00%	10	10	10.00%	10.00%
23	Morphological opposites	10	10	10.00%	20.00%	10	10	00.00%	00.00%
24	Listening comprehension	5	20	100.00%	100.00%	5	20	00.00%	60.00%
25	Reading aloud—words	10	10	20.00%	20.00%	10	10	10.00%	30.00%
26	Reading aloud—sentences	10	10	00.00%	10.00%	10	10	00.00%	00.00%
27	Reading comprehension—words	10	10	80.00%	100.00%	10	10	50.00%	60.00%
28	Reading comprehension—sentences	10	10	50.00%	60.00%	10	10	50.00%	50.00%
29	Copying	5	20	100.00%	100.00%	5	20	100.00%	100.00%
30	Overall score	**376**	**0.266**	**59.32%**	**62.25%**	**373**	**0.2681**	**43.97%**	**52.01%**

*Excluded from the overall score

* Increase in the score

* Decrees in the score

* No change

The scores in the Table 6 above reported a mix of results that included increasing, decreasing, and no change indications in the subsets of BAT. McNemar test was used to determine whether the reported differences were significant, and Crosstabs were collected to provide a better understanding of our findings.

4.1.2 Treated language (Arabic L1)

The result of the post-treatment McNemars test did not show a significant overall improvement in the treated language (Arabic) **(**McNemarstest,p = 0.31)). This is justified when considering the results of crosstab which reported that the number of responses that were right and still right was (192); whereas responses that were wrong and still wrong were (120); responses that were wrong and became right were (45) and responses that were right and became wrong scored (35). The highest frequency was for the responses in the right tabs, which evidently denotes that those improvements in (L1) were not significant.

Some subtests of the BAT showed clear gains, such as grammaticality judgment (from 60% to 80%), pointing (from 75% to 100%), simple & semi complex commands (from 30% to 80%), and reading comprehension words (from 80% to 100%). However, a closer look at McNemars' results of BAT subsets for L1 shows that it was evident that all subsets reported insignificant improvements except for Syntactic comprehension (p = 0.17) as most of the responses were in right tabs.

4.1.3 Untreated language (English L2)

The BAT scores for the untreated language, i.e., English, showed a significant improvement in the overall score. McNemars test was significant for the overall change (p = 0.001), denoting significant improvements in L2. Many of the subtests indicate higher scores in post-therapy, in particular pointing (from 60% to 90%), verbal auditory discrimination (from 27.55% to 44.40%), synonyms (from 40% to 100%), semantic acceptability(from 40% to 80%), semantic opposites (from 0 % to 20%), verbal fluency (from 0% to 66.6%), and listening comprehension (from 0% to 60%). However, the improvements on each subtest were not statistically significant. For a summary of the results, see Table (7).

Table (7): Summary of McNemars Test for the significant changes in Arabic (L1) and English (L2) before and after treatments

NO.	BAT subset	McNemars	
		AR	EN
1	Pointing	0.250	0.250
2	Simple & semi-complex commands	0.063	1.000
3	Complex commands	n/a	n/a
4	Verbal auditory discrimination	0.375	0.250
5	Syntactic comprehension	0.017*	0.124
6	Semantic categories	1.000	1.000
7	Synonyms	0.063	0.250
8	Antonyms	0.500	1.000
9	Grammaticality judgment	0.500	1.000
10	Semantic acceptability	1.000	0.219
11	Repetition—words	0.500	0.687
12	Lexical decision	0.219	0.500
13	Repetition—sentences	1.000	1.000
14	Series	1.000	1.000
15	Verbal fluency	0.500	0.500
16	Verbal fluency (no. of words)*	//	//
17	Naming	0.125	1.000
18	Sentence construction	1.000	1.000
19	Sentence construction (no. of words)*	//	//
20	Semantic opposites	0.125	0.500
21	Derivational morphology	0.500	1.000
22	Morphological opposites	1.000	n/ a
23	Mental arithmetic	n/ a	1.000

NO.	BAT subset	McNemars	
		AR	EN
24	Text listening comprehension	n/ a	0.250
25	Reading aloud—words	1.000	0.500
26	Reading aloud—sentences	1.000	n/ a
27	Text reading comprehension	1.000	1.000
28	Copying	n/ a	n/ a
29	Word dictation	1.000	n/ a
30	Sentence dictation	n/ a	n/ a
31	Reading comprehension—words	0.500	1.000
32	Reading comprehension—sentences	1.000	1.000
Overall score		**0.314**	**0.001***

-Spontaneous speech and discerption subsets were excluded from McNemars as coding were not a dichotomy

*Significant at ($p \leq 0.05$)

4.1.4 Linguistic Clusters

Because some subtests included few items (semi-complex commands, complex commands, semantic categories, synonyms, series, listening comprehension, and reading comprehension for paragraphs), it was difficult to calculate statistical significance with such few items. Therefore, we followed Paradis and Libben (1987), combining the small subtests into linguistic clusters in order to provide more robust results. Four clusters were established, namely phonology, morphology, syntax, and semantics. Scores for Pre- and Post-treatment were calculated in L1 and L2 (see Table (8) for more details)

Table (8): BAT results in Arabic (L1) and English (L2) for linguistic clusters

NO.	Linguistic level	Arabic (L1)				English (L2)			
		Score		Result		Score		Result	
		N	Weight	Pre	Post	N	Weight	Pre	Post
1	**Phonology**	75	1.333	58.65%	58.65%	75	1.333	41.32%	50.65%
2	**Morphology**	25	4	36.00%	28.00%	25	4	16.00%	12.00%
3	**Syntax**	127	0.787	53.51%	69.25%	127	0.787	51.15%	55.87%
4	**Semantics**	51	1.96	82.32%	56.84%	51	1.96	29.40%	55.96%

* Increase in the score

* Decrees in the score

* No change

4.1.4.1 Treated language Arabic (L1)

The BAT results showed an overall improvement in syntax as scoring increased from (53.51%) to (69.25%). The improvement was significant; McNemars test scored (p = 0.001). This result was expected as we focused on complete sentences during the therapy. On the contrary, McNemars test showed a significant decrease with respect to the semantics scores (the test significance scored (p = 0.000) (semantics scores dropped from 82.32% to 56.84%). The decrease was not expected as the semantic domain was one of the targets of the treatment. In addition, the test results showed a decrease in morphology scores, but this was not significant (McNemars test, $p=0.625$). The BAT scores did not show any change in phonology (58.56% pre-post treatment).

4.1.4.2 Untreated language (English (L2))

A significant generalization was found in one linguistics domain, i.e., semantics. The scores increased from (29.40%) to (55.96%) (McNemars test, p = 0.013). A decrease in morphology was observed (from 36% to 28%); however, McNemars

reported insignificant influence (p = 1.000), denoting a marginal decrease. The two remaining clusters scored a marginal improvement along with insignificant values by the McNemars test (see Figure (5) and Table (8)).

Figure (5): Scores of BAT in Arabic (L1) and English (L2) according to linguistic levels

Table (9): Results of McNemars Test and crosstabs for the significant changes in Arabic (L1) and English (L2) before and after treatments according to linguistic levels

No.	Linguistic level	Arabic (L1)					English (L2)				
			Post			McNemars		Post			McNemars
1	Phonology	Pre	Wrong	26	5	1.000	Pre	Wrong	35	9	0.065
			Right	5	39			Right	2	29	
			Post			McNemars		Post			McNemars
2	Morphology	Pre	Wrong	15	1	0.625	Pre	Wrong	21	0	1.000
			Right	3	6			Right	1	3	
			Post			McNemars		Post			McNemars
3	Syntax	Pre	Wrong	34	25	0.001*	Pre	Wrong	39	23	0.429
			Right	5	63			Right	17	48	
			Post			McNemars		Post			McNemars
4	Semantics	Pre	Wrong	9	0	0.000*	Pre	Wrong	22	14	0.013*
			Right	13	29			Right	3	12	

*Significant at ($p \leq 0.05$)

4.1.5 Change effect scores

Effect size is an essential measure that illustrates the difference between the pre-test and post-test results. It also indicates the degree of effectiveness of the treatment (Wisenburn and Mahoney, 2009; Knop,2013). There are many measures for effect size, but Cohen's d (Field et al., 2012, cited in Knop,2013) is one of the most reliable measures. Since the researchers did not collect multiple baseline measures, it is not possible to calculate effect size using this way. Therefore, the researchers decided to estimate the effect size by subtracting the pre-treatment score from the post-treatment score. This provides the effect score of the treatment of the treated language and a generalization effect score of the untreated language (Dickey and Yoo, 2010; Amberber, 2011, cited in Knop,2013).

The effect score of the treated language, Arabic, was 2.9%. Some of the targeted subtests in the treatment showed marginal effect score (grammaticality judgment 20%, reading sentences aloud 10%, reading comprehension for words 20%, syntactic comprehension 13.8%). The patient's performance fell in other subtests that included items targeted in the treatment ((verbal auditory discrimination, synonyms, antonyms, semantic opposites, verbal fluency, semantic acceptability. Although series were not the focus of the therapy, the effect size was 33.3%. (See Table (10)).

There was a generalization effect of 8.04% in the overall results of the untreated language. i.e., English. Various subtests that were covered in the treatment had a generalization effect of up to 40% (synonyms 60%, semantic acceptability 40%, verbal fluency 66.6%, text listening comprehension; see Table). Other subtests that were expected to show a generalization effect because of the focus of the study had small to no change (verbal auditory discrimination, syntactic comprehension, semantic opposites, reading aloud words, derivational morphology). A decrease in the effect size was observed in terms of some of the subtests although they included aspects that were covered in the treatment (semantic categories, antonyms, grammaticality judgment) (see Table(10)).

Table (10): The comparison of treatment gains in Arabic (L1) and English (L2) before and after treatment

No.	BAT subset	Gain (%)		Arabic vs. English	
		Arabic (L1)	English (L2)	Pre	Post
1	Pointing	25	30	A > E	A > E
2	Simple & semi-complex commands	50	0	E > A	A > E
3	Complex commands	0	0	A = E	A = E
4	Verbal auditory discrimination	-16.65	16.65	A > E	A > E
5	Syntactic comprehension	13.8	10.35	E > A	A > E
6	Semantic categories	0	-20	A = E	A > E
7	Synonyms	-100	60	A > E	E > A
8	Antonyms	-20	-10	A > E	A > E
9	Grammaticality judgment	20	-10	A > E	A > E
10	Semantic acceptability	-10	40	A > E	A > E
11	Repetition—words	6.66	6.66	A > E	A > E
12	Lexical decision	13.32	-6.66	E > A	E > A
13	Repetition—sentences	0	0	A > E	A > E
14	Series	33.33	33.33	A = E	A = E
15	Mental arithmetic	0	-6.66	E > A	A = E
16	Verbal fluency	-66.67	66.66	A > E	E > A
17	Verbal fluency (no. of words)*	//	//	//	//
18	Naming	25	5	A > E	A > E
19	Sentence construction	6.66	0	A > E	A > E
20	Sentence construction (no. of words)*	//	//	//	//
21	Semantic opposites	-40	20	A > E	A > E
22	Derivational morphology	-20	0	A > E	A > E
23	Morphological opposites	10	0	A > E	A > E
24	Listening comprehension	0	60	A > E	A > E
25	Reading aloud—words	0	20	A > E	E > A
26	Reading aloud—sentences	10	0	A = E	A > E
27	Reading comprehension—words	20	10	A > E	A > E
28	Reading comprehension—sentences	10	0	A = E	A > E
29	Copying	0	0	A = E	A = E
30	Overall score	2.93	8.04	A > E	A > E

*Excluded from overall score

4.1.6 Results of the Action-naming test

McNemars test was used to determine the significant improvements in verb production in AR and EN.

4.1.6.1 Treated language (Arabic)

There was a significant improvement in the overall scores of Arabic (McNemars test, $p=0.00$).Table(11) shows significant improvements in both trained and untrained verbs of AR. Moreover, it illustrates a cross generalization with respect to the untrained verbs (MecNemars test showed a significant increase,$p=0.035$). We also observed significant improvement in the results of semantically and phonologically cued verbs as *P* values didn't exceed (0.05) (Table(11))

Table (11): Results of McNemars test for significant improvements in action naming test – AR (L1)

Naming set	**N**	**Score**			**Post**			**McNemars**
				Pre		Wrong	Right	
AR - overall	**120**	**Pre**	**Post**		Wrong	40	47	**0.000***
		27.49%	57.48%		Right	11	22	
AR - untrained	**60**	**Pre**	**Post**		**Post**			
		23.32%	41.65%	**Pre**		Wrong	Right	**McNemars**
					Wrong	29	17	**0.035***
					Right	6	8	
AR - trained	**60**	**Pre**	**Post**		**Post**			**McNemars**
		31.65%	73.30%	**Pre**		Wrong	Right	
					Wrong	11	30	**0.000***
					Right	5	14	
AR – trained - Phonologically	**30**	**Pre**	**Post**		**Post**			**McNemars**
		26.64%	63.27%	**Pre**		Wrong	Right	
					Wrong	8	14	**0.013***
					Right	3	5	
AR – trained - Semantically	**30**	**Pre**	**Post**		**Post**			**McNemars**
		36.63%	83.25%	**Pre**		Wrong	Right	
					Wrong	3	16	**0.001***
					Right	2	9	

***Significant at ($p \leq 0.05$)**

4.1.6.2 Untreated language (English)

Following verb treatment, we found no significant improvements in verb production in EN considering that the significance value of the test scored (P = 0.057), exceeding (0.05), evidently showing that patient DB did not achieve any significant improvements in verb production in L2. Therefore, no cross-language transfer was reported. (See Table(12))

Table (12): Results of McNemars test for significant improvements in action naming test – EN (L1)

		Pre	**Post**		**Post**			**McNemars**
EN	**120**	4.17%	10.83%	**Pre**		Wrong	Right	
					Wrong	104	11	**0.057**
					Right	3	2	

*Significant at ($p \leq 0.05$)

5. Discussion

This study provided a language treatment targeting verbs in complete sentences by a bilingual speaker with non-fluent aphasia. In addition to delivering semantically and phonologically cued verbs therapy, we provided a communication-based treatment. The purpose of the study was to examine whether a treatment in the dominant language (L1, Arabic) can lead to cross-language transfer, i. e., improvements in the untreated language (L2, English). The study also examined within-language generalizations resulting from L1 treatment.

Following treatment in the patients' L1 (dominant language), there was no significant improvement in the overall scores of the treated language, Arabic. This result can be explained by virtue of the subjects' near-ceiling performance in Arabic in many of the BAT subtests. However, treatment-related gains were observed; we found significant improvements in the syntax subtests which was predicted because it was one of the treatment targets.

Cross-language -transfer was reported from L1 to L2 given that significant improvements in the overall BAT English results were observed. Each subtest of the untreated language was improved (although it was not statistically significant).

This finding is in fact in line with the results of Ansaldo et al. (2010) and Conner et al. (2018) whereby a cross-language generalization was found after treating L1.

Furthermore, this result is consistent with Goral et al.'s (2012) study which suggested that treating the language of the environment was one of the factors that facilitated cross-language transfer. On the other hand, this finding is incompatible with Edmond and Kiran (2006), who administrated a semantic treatment for balanced and unbalanced bilinguals with aphasia. They concluded that a cross-language treatment is likely to occur from L1 to L2 if the subject is a balanced bilingual speaker. Although the subject of the current study is unbalanced bilingual (Arabic is the premorbid dominant language and the most recovered one.), a cross-language generalization was found from treated L1 to untreated L2.

One surprising result related to the significant decrease in the semantics scores of the treated language, i.e., Arabic. This inhibition was not expected as the semantic domain was one of the targets of the therapy. Inhibition was reported in previous studies, such as Goral, Naghibolhosseini, and Conner (2013) who found "asymmetric inhibition of the stronger language following a period of activation of the weaker one" (p. 574). Goral et al. (2013) explained their results according to the parallel activation hypothesis which assumed that all the languages of multilingual speakers are active when the speaker uses one of his/her languages. Therefore, the multilingual speaker is always engaged with the selection and inhibition processes. "When bilinguals perform a task in one language, they need to inhibit their other, non-target language(s) and that stronger inhibition is required when the task is performed in the weaker language than in the stronger one" (Goral et al.,2013, p. 564)

We reported generalization in some outcome measures. A within-language-generalization was reported as the untrained verbs scores achieved significant improvements (from 23.32% to 41.65%). The within-language generalization supports the theory of a shared storage model as explained in *The Revised Hierarchical Model* (Kroll and Stewart, 1994; Figure 3). According to the RHM model, a bilingual speaker possesses two different but connected lexicons and a shared conceptual level. Catic (2021) illustrated that "Bilinguals hold memory of two languages in their brain. It is possible to think of these storages as two separate boxes, one for each language. These two boxes describe the lexical memories. In addition to that, there is a third box which holds all the conceptual memories the Bilingual knows about in both of their acquired languages" (p. 3). The link between L1 and the shared conceptual memory is strong. While the link between the conceptual memory and L2 is weaker. Nevertheless, the link from L2 to L1 at the lexical level is stronger than that from L1 to L2 (DONG et al. 2005). In this respect, Croft et al. (2010) mentioned that because "semantic to L1 connections are stronger than semantic to L2 connections. This may suggest that therapy in L1 will bring about stronger within language gains than therapy in L2" (p. 50).

6. Conclusion

The findings of the current study suggest that a language treatment in the stronger language, L1, of a bilingual aphasic speaker leads to a cross-language transfer as well as a within-language generalization. We suggest that a cross-language - generalization is reported due to the structural overlap between the two languages. L1 has stronger links with the semantic/conceptual system, which explains the within-language generalization finding. The present study has limitations as multiple baselines were not conducted becuase the patient could not participate for a longer period of time due to travel commitment. Multiple baselines could be conducted in future research to help determine whether semantic or phonological therapy plays a role in a cross-language generalization.

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