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Effects of language proficiency and language of the environment on aphasia therapy in a multilingual

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Abstract

We examined the relative proficiency of four languages (Spanish, German, French, English) of a multilingual speaker with aphasia, JM. JM's self-rated proficiency was consistent with his naming accuracy for nouns and verbs (The Object and Action Naming Battery, Druks & Masterson, 2000) and with his performance on selected subtests of the Bilingual Aphasia Test (Paradis & Libben, 1987). Within and between-language changes were measured following two periods of language treatment, one in a highly-proficient language (Spanish) and one in a less-proficient language (English). The various outcome measures differed in their sensitivity to treatment-associated changes. Cross-language treatment effects were linked to the language of the environment at the time of testing and to relative language proficiency.

Keywords

aphasia; BAT; cross-language; generalization; multilingual; treatment

Introduction

Early studies of language treatment in polyglot aphasia suggest that treatment in one of the languages of multilingual speakers with aphasia benefits the non-treated languages as well (e.g., Fredman, 1975; Voinescu, Vish, Sivian, & Maretsis, 1977). For example, self-reports from multilingual speakers with aphasia have revealed that treatment in the second language (L2) positively affected the non-treated first language (L1), regardless of the specific structural and genetic relations between the treated and untreated languages (Fredman, 1975). Fredman's results were based on reports from 40 bilingual patients who had immigrated to Israel as adults and received speech and language treatment in their late-learned L2, Hebrew. It is of interest to note that for these participants, the language of treatment was the language of the environment at the time of treatment. In another early study, Voinescu et al. (1977) demonstrated that, for their highly proficient polyglot speaker with aphasia, treatment in Romanian – a language he learned in childhood but not his mother tongue – resulted in improvement of production in the treated language as well as in the other languages, as measured by verbal responses to interview questions. In both studies,

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the treatment targeted a variety of skills using a number of treatment techniques. These early results are intriguing but provide insufficient information about the specific language skills that might have benefited from the treatment.

In the past decade, researchers have re-addressed the question of cross-language generalization following aphasia treatment, employing objective measures of language abilities prior to and following intervention (e.g., Edmonds & Kiran, 2006; Goral, Levy, & Kastl, 2010; Miertsch, Meisel, & Isel, 2009; for review see Ansaldo, Marcotte, Scherer, & Raboyeau, 2008; Faroqi-Shah, Frymark, Mullen, & Wang, 2010). A systematic review of 14 studies of aphasia treatment in bilingual and multilingual individuals (Faroqi-Shah et al., 2010) revealed that most studies demonstrated cross-language treatment generalization, especially when the language of treatment was the participants' L1. In reviewing pertinent recent studies we identified two specific patterns of results. The first pattern is demonstrated by the findings of cross-language treatment generalization between two highly proficient languages as well as from a less-proficient language to a more-proficient language (but not from a more-proficient to a less-proficient one). For example, Gil and Goral (2004) found improvement in their participant's non-treated L1 Russian following treatment in Hebrew, the participant's L2. Treatment addressed all language modalities and skills; performance was measured by The Israeli Loewenstein Aphasia Test (ILAT). Treatment in Hebrew was provided during the first three months following the onset of his aphasia and thus the authors acknowledge that processes of spontaneous recovery may have contributed to the pattern of cross-language improvement observed. However, two additional studies, one with participants in their chronic phase, have reported a similar pattern. Edmonds and Kiran (2006) reported positive treatment effects for two participants (P2 and P3), from their weaker Spanish to their stronger English, but not in the other direction (from their stronger English to their weaker Spanish). Both participants reported that they had acquired their two languages from birth but used English more frequently than Spanish as adults. The authors suggested that when the proficiency levels of the two languages of a bilingual differ, cross-language generalization may be found in one direction, that is, from the weaker language to the stronger language.

A third participant in the study (P1) had a balanced proficiency in her two languages, was treated in Spanish only, and showed improvement in the treated Spanish as well as cross-language generalization to her untreated English. The same pattern of transfer between two highly proficient languages was reported in another study. Khamis, Olenik, and Gil (1996) reported overall transfer of therapeutic benefits from their participant's treated language, L2 (Hebrew) to his non-treated language, L1 (Arabic); treatment in L1 was not reported in their study.

By contrast, a second pattern of results reported in the literature demonstrates a lack of generalization from the treated language to the (non-treated) first-acquired language. In three separate studies with multilingual individuals, cross-language generalization was found from the treated language to a non-treated language but not to the participants' non-treated L1. In Filiputti, Tavano, Vorano, de Luca, and Fabbro (2002), an individual with fluent aphasia was treated in Italian, his L2, and tested in his four languages pre- and post-treatment. The results demonstrated improvement in the treated language, Italian (L2), as well as in L3 (Friulian) and L4 (English), but not in his L1 (Slovenian). The authors noted that their participant had not used his first language for 35 years prior to the stroke. A similar finding was reported in Miertsch et al. (2009), who also found no treatment generalization to their participant's stronger L1, German, in contrast to cross-language generalization from the treated L3, French, to his non-treated L2, English. Here, however, L1 was being used by the participant prior to and at the time of the study. Similarly, Goral, Levy, and Kastl (2010) found cross-language generalization between English and French –

in this case, from the treated L2 (English) to the untreated L3 (French) – but again not to the participant's L1 (Hebrew). In both the Miertsch et al. and the Goral et al. studies, the first language of the participants was better recovered than the other languages and ceiling effects may account for the apparent lack of cross-language generalization.

Furthermore, the degree of linguistic similarity between the treated and untreated languages may affect cross-language facilitation. As an example, Kohnert (2004) found positive cross-language effects from the treated Spanish to the untreated English in a Spanish-English bilingual with non-fluent aphasia, although the improvement was noted for cognate words (e.g., *bicycle/bicicleta*) and not for non-cognates (e.g., *apple/manzana*). Cognate facilitation effects reported in a variety of psycholinguistic studies with bilingual individuals (e.g., Dijkstra, Moscoso del Prado Martín, Schulpen, Schreuder, & Baayen, 2005) are one type of cross-language facilitation, but we note that Edmonds and Kiran (2006) reported cross-language improvements not only for cognate translation equivalents but also for semantically related words across languages. Similarities and differences in orthography have also been implicated in contributing to cross-language effects. For example, Watamori and Sasanuma (1978) reported cross-language generalization between English and Japanese, but not in the written language domain.

The studies discussed above differ from each other not only in the language history of their participants, but also in the focus of treatment provided, the outcome measures employed, and the language of the social environment during treatment. All of these variables have been proposed to account for the presence and absence of cross-language generalization (e.g., Ansaldo et al., 2008; Edmonds & Kiran, 2006; Goral et al., 2010; Paradis, 2004; 2009) but the relative contributions of these variables and the way they interact with each other are not well understood.

In the present study we had the opportunity to examine cross-language generalization in a multilingual speaker following two consecutive treatment phases, one administered in the participant's highly proficient/better recovered language and another in a language of lower proficiency. We asked whether we can detect cross-language generalization and if so whether generalization effects depend on a) relative proficiency/recovery of the treated language and the untreated languages; b) the language of environment at the time of treatment; and c) the specific language skills measured.

Method

The Participant

Our participant (JM) was a 49 year old, well-educated chemist, who at the age of 44 suffered a left ischemic stroke in the region of the left medial cerebral artery. The stroke resulted in right upper- and lower-body hemiparesis and non-fluent aphasia, characterized by effortful and slow language production, short utterance length, and word finding difficulty.

As a native of Barcelona (Spain), Catalan and Spanish were his first acquired languages; Catalan was the language spoken at home with family and friends and Spanish was the main language at school. JM rated his Catalan and Spanish language production and comprehension skills (pre-onset) at 9 on a 1-9 scale, and his written skills as better in Spanish than in Catalan (9 and 5, respectively).

His career required substantial knowledge of French, English, and German, in which he developed both oral and literate proficiency. JM learned these later-acquired languages through academic instruction beginning at age 5 for French and 14 for German and English. Of these languages, JM judged his pre-morbid proficiency to be strongest in German,

followed by French and English, which were at equivalent proficiency levels. He reported using Catalan with his family, friends, at work, and for leisure; Spanish at work, reading and leisure; English during travel and reading; French during travel; and German for work and travel. At the onset of this study, five years post the aphasia onset, JM ranked the five languages from most to least proficient in terms of current general proficiency (across communicative contexts): Catalan, Spanish, German, French, and English (see Table 1).

Following the stroke, he received speech therapy in Catalan and Spanish for five years, approximately four visits per week. JM also received private instruction in German twice weekly from a native-speaking professor. The present study took place in New York during JM's extended visit to the U.S. When visiting the U.S. in the past, JM received treatment in Spanish three times weekly. For the duration of the present study, he did not receive any additional treatment.

Pre- and post-treatment measurements

Before the beginning of the study, one of the researchers (JR) explained the study to JM (in Spanish) and JM signed an informed consent form. He was then administered the Object and Action Naming Battery (Druks & Masterson, 2000) in Spanish (a language in which he had received treatment from JR in the U.S.). A subset of the actions and the objects for which JM did not produce the target name were selected for the pre- and post-treatment testing. We also asked JM to self-rate his pre- and post-stroke proficiency in the four languages of the study using a Likert scale ("9" indicating highest, native like proficiency; "1" indicating poor abilities).

Pre- and post-treatment testing—Pre-treatment testing was administered in consecutive days in Spanish, English, French, and German¹. Each language was tested by a native speaker (except German which was tested by a highly proficient speaker of the language). In anticipation that the people administering the evaluation and JM would not always be able to meet at the same location, all testing sessions were conducted via teleconferencing software (Skype™). During Skype testing, JM was able to see and hear each evaluator, and the evaluators were able only to hear JM's responses (but not see him). JM was provided with a digital audio-recording device (Handy Recorder, Zoom©) and was given verbal instructions in each language of testing on how to start and terminate recording of the testing session. Binaural headphones were provided and used to avoid feedback. Each testing session lasted about an hour.

Following a brief conversation, four subtests from the language production portion of the Bilingual Aphasia Test (BAT, Paradis & Libben, 1987) were administered: Verbal Fluency, Semantic Opposites, Sentence Construction, and Description. Our rationale in selecting these subtests was that they assess lexical-retrieval abilities – which were targeted in the treatment we administered – in different contexts in a format comparable across the four languages. In the Verbal Fluency task, JM was asked to generate as many words as possible beginning with a given sound within one minute. In the Semantic Opposites subtest, JM listened to single words and had to produce the semantic opposite of each one (e.g., when he heard "tall" he was expected to say "short"). In the Sentence Construction subtest, JM listened to a series of 2-5 words and was instructed to generate for each series a sentence that contained those words. The first three subtests were administered with no visual support. For the fourth subtest (Description), JM was provided with a panel from the BAT

¹We treated JM in Catalan prior to the treatment in Spanish and tested him in Catalan in each testing session; however, due to technical reasons, no Catalan data are available.

stimulus booklet of six wordless line drawings that formed a short story and was instructed to tell the story depicted in the pictures.

Following the BAT subtests, two picture-naming tasks were administered. JM was instructed to name a series of line drawings consisting of a) 72 objects and b) 40 actions selected from the Object and Action Naming Battery (Druks & Masterson, 2000). Of the 72 objects, 33 were cognates in Spanish and French, 17 in Spanish and English, 14 in Spanish and German, 31 in English and German, and 21 in English and French; seven objects were cognates in all four languages. Of the 40 actions, 11 were cognates in Spanish and French, six in Spanish and English, two in Spanish and German, 15 in English and German, and six in English and French; one item (*floating*) was a cognate in all four languages (for the list of items see Appendix A). The pictures were displayed on a computer screen using PowerPoint (Microsoft™). A number appeared on the computer screen followed by a single drawing. JM advanced each drawing via mouse-click. The mouse pad was positioned so that JM could make use of his left hand during testing. All responses were audio-recorded and transcribed. Scoring procedures are described below.

Post-treatment testing in each language was conducted in random order² starting 1-3 days following the last session of each of two treatment phases (in Spanish and English; see below). A total of three testing times are reported (pre-treatment in Spanish, post-treatment in Spanish, post-treatment in English).

Treatment protocol

Treatment schedule—Two consecutive treatment phases, one in Spanish and one in English, were administered each by a native speaker of the treated language. Both clinicians were certified/licensed speech-language pathologists with over nine years of experience. Each treatment phase comprised 22-25 hours administered over a period of 5 weeks, with treatment sessions lasting between 75 minutes to 120 minutes. All sessions were held in a quiet room.

Treatment items—Two comparable lists of 18 objects and 10 actions each (for the list of treated items, see Appendix A) were used in each of the two treatment phases. In each treatment phase, a total of 48 items were treated: the 28 items from the subset plus an additional 20 items (12 objects and 8 actions). The additional items added to the variety of the treatment sessions but were not tested pre- and post-treatment. In addition to the line drawings used for testing, two different color pictures were employed for the training of each target word to add variety to the stimuli used and to ensure that successful naming was not restricted to the repeatedly used line drawings.

Treatment activities—Each treatment session comprised three activities, administered for the object and action targets separately. A third of the target items were targeted in each treatment session such that each target word was presented and practiced six times in the course of each treatment phase. The first activity was a modified semantic feature analysis (SFA, Boyle, & Coelho, 1995). The participant was presented with a picture in the center of the page and was asked to generate an appropriate feature in each of five categories. The categories for the objects were: superordinate category, use/action, physical properties, location, and association (e.g., *cow*: animal; milking/grazing; four legs/big; farm/meadow/field; milk/sheep). The categories for the actions were: verb type, actor, object, location, and

²Order of testing: Pre Spanish treatment (Catalan), English, Spanish, French, German
Post Spanish treatment: English, German, French, Spanish, (Catalan)
Post English treatment: Spanish, English, German, French, (Catalan)

association (e.g., peeling: active/causative/change of state; person/cook; orange/banana; kitchen/restaurant; knife/eating/fruit). The clinician provided cues and modeled the responses as needed. During the first sessions, the clinician wrote down the participant's responses around the picture and these were used in the second activity (see below); in later sessions, the clinician recorded the participant's responses on a separate page. After the features were produced, the participant was instructed to name the picture; the written word, cues and modeling were provided and faded as needed.

The second activity in each session was a sentence generation task. Using the same target words, the participant was instructed to verbally produce a sentence containing the target word. In the first few sessions of the treatment, the maps with the target picture, the written word, and the written features remained in front of the participant and served as a cue. Later on, only the picture (with no written information for the five semantic features) was presented and the participant was asked to generate a sentence for the target word. Modeling and cuing were provided as needed.

The third activity was a rapid naming task. Here, the participant was presented with the pictures of the target words and instructed to name them as quickly as he could. No cues or models were used in this activity, with the exception of initial-phonemic cues in the first few sessions.

Fidelity of treatment was confirmed by periodic discussions among the team members and by reviewing notes taken during treatment. Care was taken that the two clinicians provided similar instructions, assistance, and feedback during the treatment sessions.

Analysis and Results

Results are provided below for relative proficiency ranking, within-language performance, and cross-language effects for the BAT subtests followed by the two Picture Naming tasks. Percent change is noted for the BAT performance; the McNemar test is applied to assess change in the Picture Naming tasks.

I. Bilingual Aphasia Test

The BAT subtests were scored according to the BAT manual (Paradis & Libben, 1987) with minor modifications noted below. For the Verbal Fluency, the total number of words that JM produced that began with the target sound were counted for each sound and summed across the three phonemes administered. Words that did not begin with the target sound, repeated words, and words in a language other than the tested language were not included in the count. For the Semantic Opposites subtest, the total correct responses in the language tested were counted, for a maximum score of 10. For the Sentence Construction subtest, only responses that comprised a grammatical and meaningful sentence and contained all the target words provided were counted as correct, for a maximum score of five. For the Description subtest, we supplemented the scoring included in the BAT instructions (i.e., questions 344-346), which revealed little change across testing times, with an analysis of the transcribed story JM had produced, considering a number of variables at the word and clause level. For the number of words produced we counted all words excluding false starts, repetitions, and code-switches. As well we tallied the number of nouns and verbs he produced in each target language. We counted the number of clauses by counting each clause produced, whether grammatical or not, defining clauses both by intonation and content (for example, a clause could comprise a part of a complex sentence, a simple sentence, or one word). We then calculated the percent of grammatical clauses out of all clauses produced.

Relative language proficiency pre-treatment—Pre-Spanish treatment performance by JM on the four BAT subtests did not reveal a clear ranking pattern of language proficiency (see Table 1). As expected, Spanish scores on each of the BAT measures outranked all other languages measured. English and French scores were comparable on Verbal Fluency, Semantic Opposites, and Sentence Construction, but English performance on the Description task was extremely low. French and German scores on the Description measures (number of words, clauses, and grammatical clauses) were comparable and higher than those in English (see Table 2 for the BAT scores across the languages).

Within-language treatment-associated change—A significant change in performance on the BAT subtests was categorized as a pre-determined 40% increase or decrease in scores within subtest and across consecutive testing times (e.g., Kiran & Johnson, 2008; Raymer et al., 2007). Table 2 presents JM's scores in each subtest in each language in each testing time.

Post Spanish treatment: No significant changes in scores were noted across the Spanish BAT subtests following Spanish treatment.

Post English treatment: A greater than 40% increase was observed on three of the four subtests: an increase in total words retrieved in the Verbal Fluency subtest, in total number of complete sentences generated on the Sentence Construction subtest, and a dramatic improvement in the Description task following treatment in English. Compared to a total of seven words and no complete sentence pre-treatment, JM produced a narrative of 75 words, increasing both the number of verbs and the number of nouns. His post-treatment narrative comprised 12 clauses, a third of which were grammatically correct.

Cross-language generalization

Post Spanish treatment: Treatment in Spanish, JM's more proficient language, influenced performance in the non-treated languages primarily on two BAT subtests: Verbal Fluency and Description. Specifically, JM produced significantly fewer English words but significantly more French words on the Verbal Fluency task after Spanish treatment. In addition, JM produced a significantly greater number of clauses per narrative across all languages after Spanish treatment; however, the number of grammatical clauses only increased in the German narrative.

Post English treatment: Treatment in English, JM's less proficient language, influenced BAT performance in the non-treated languages somewhat differently. German Verbal Fluency was significantly better after English treatment, whereas Spanish and French word retrieval did not change significantly. In the Description subtest, JM increased the number of French clauses he attempted, though not a significantly greater number were grammatical. He also produced more verbs (but not more nouns) in French. In contrast, JM produced a greater number of grammatical clauses in German as well as greater number of nouns.

In summary, improved performance on the BAT production subtests was observed for English following treatment in English but not in Spanish following treatment in Spanish. As well, cross-language change was observed in French on Verbal Fluency following treatment in Spanish and on the number of clauses produced in the Description subtest following both treatment in Spanish and treatment in English. Change was also found in German in Verbal Fluency following treatment in Spanish, and in the number of clauses and number of grammatical clauses in the Description subtest following treatment in Spanish and in English, respectively, and an increase in the number of words produced in English in the Description (but not in Verbal Fluency) following treatment in Spanish.

II. Object and Action Picture Naming

The picture-naming tasks were scored for each language by the respective evaluator. Each response was categorized as correct target, correct non-target (i.e., an appropriate response for the picture but one that differed from the target according to the battery manual, e.g., “woman” for *waitress*, “play” for *pulling*), or incorrect. When the response contained more than one word, we selected the best response in the string. In addition, we rated each response for whether it was produced immediately (i.e., a correct response produced with no intervening words and within five seconds from the end of his production of the item number), whether it was a code switch (i.e., whether the only response was given in a non-target language), whether the word was treated in the treatment phases, and whether it was a cognate (i.e., whether it was a cognate word to one or more of the other three languages).

We defined cognates as follows: two translation equivalents that share three consecutive sounds (e.g., *lune* - *luna*) or three consonants (e.g., *curtain* - *cortina*). We allowed for some regular correspondence between sounds in a given pair of languages, such as the /d/ - /th/ as in the English *feather* and German *feder*. If there was more than one such “shift”, we considered additional variables, such as the number of syllables and additional consonants in the word. Thus in the example above, there are two shifts, one in each syllable (the first vowel, the second consonant), but the number of syllables is the same as is the last consonant. Two authors rated the words in each pair of languages independently and the ratings were compared. Any disagreements were resolved by a discussion with two additional authors.

Relative language proficiency pre-treatment—The ranking of the overall correct scores on the Object and Action Naming Task was largely consistent with JM’s self rating. As was the case in the self-rating both pre- and post-CVA and in the BAT subtests, Spanish was found to be the most proficient language. Consistent with JM’s self-rating, German and French were less proficient, and English was least proficient (See Table 1).

Within-language treatment-associated change—Within-language treatment-associated changes on object and action naming were evaluated using the McNemar test for paired analysis, a non-parametric alternative to the t-test for related-measure study designs. Total accuracy (correct plus appropriate responses), number of immediate responses, and number of code-switched responses were analyzed.

Post Spanish treatment: No significant change in total accuracy, immediacy, or code-switches was noted on JM’s Spanish naming performance following treatment in Spanish (see Figure 1).

Post English treatment: A significant increase in English object naming (McNemar, corrected for continuity: $p < 0.001$) and action naming (McNemar $p < 0.01$) was noted after English-language treatment was administered. JM increased the number of objects labeled correctly from 14 to 40 and the number of actions labeled correctly from 3 to 17. Furthermore, JM improved his naming latency by generating immediate, correct responses significantly more often after the treatment in English than before, in both object naming (McNemar $p < 0.001$) and action naming (McNemar $p < 0.05$). There was no change in the frequency of code-switched words when attempting to label objects or actions.

Cross-language generalization

Post Spanish treatment: Spanish treatment did not significantly change object or action naming accuracy, latency, or number of code-switched words produced in any of the non-treated languages. Significantly more cognates of Spanish, as compared to non-cognates,

were correctly produced in all non-treated languages following the treatment in Spanish. Chi-square analyses revealed a significant difference between the proportion of correct and incorrect cognates versus correct and incorrect non-cognate objects in German ($X^2 = 5.71$, $p < .05$), French ($X^2 = 17.13$, $p < .001$), and English ($X^2 = 6.71$, $p < .01$), and actions in French ($X^2 = 18.47$, $p < .001$). There was no difference between the accuracy in the non-treated languages of items that were treated in Spanish and items that were not treated.

Post English treatment: Treatment in English did not have an effect on object naming accuracy or latency in JM's other three languages. Here, too, cognates of English were more often correct than incorrect, compared to non-cognates. This was true for the objects named correctly in French and in German ($X^2 = 7.53$ and 7.52 , both $p < .01$) and for actions correctly named in Spanish ($X^2 = 7.39$, $p < .01$). Of the items correctly named in the non-treated languages, there was no significant effect of those items that were treated in English versus those that were not treated. There was a significant increase in code-switching during French testing (McNemar $p < 0.05$), with eight of the 11 code-switched words occurring in English (only one item was a cognate of English). In the action naming, by contrast, there was a significant decrease of French naming accuracy (McNemar $p < 0.05$). There was also a significant change in the number of code-switched words used during German action naming after English treatment (McNemar $p < 0.05$), with five of the six words occurring in English, two of which were cognates of English.

In summary, we found an increase in JM's accuracy in English object and action naming following treatment in English but little change in his accuracy levels in Spanish following treatment in Spanish. No cross-language effects were observed following treatment in Spanish. Evidence for increased code-switching to English during testing in German and in French, and decreased action naming accuracy in French were noted following treatment in English. Of the objects and actions named, cognates of the language that was treated were more likely to be accurately produced in the non-treated languages than non-cognates of the treated language. Finally, no treatment effects were associated with a particular increase in accuracy on the treated items as compared to the non-treated items.

Discussion

Four production subtests of the BAT and two picture-naming tasks were used to assess the relative proficiency of four languages of a polyglot speaker with aphasia and to measure change in his language performance following intense language treatment. All measures converged in demonstrating that our participant's Spanish remained his most proficient language, but inconsistencies were noted among the three less-proficient languages across the measures. Treatment in Spanish, JM's most proficient language, yielded little change across all measures in Spanish; nor was change observed in any of the three untreated languages. By contrast, a significant increase in language production was found in English skills across all measures following treatment in English. Moreover, changes in the non-treated languages were also obtained following treatment in English, albeit not on all measures in all languages. Specifically, whereas picture-naming accuracy did not increase – and even decreased – in the non-treated languages following treatment in English, JM generated more words in the fluency task and longer narratives in two of the untreated languages, namely, German and French. We return to this differential naming and generalization effect below. By contrast, treatment in English did not significantly change JM's performance in Spanish.

These findings are largely consistent with both patterns of cross-language generalization discussed above. In accordance with previous results (e.g., Edmonds & Kiran, 2006), we too did not find cross-language treatment effects from a more proficient language – Spanish in

our case – to the less-proficient languages. However, we note, there was little change in Spanish itself following treatment in Spanish, which may have contributed to the lack of cross-language generalization following the treatment in Spanish. We suggest that the language of environment at the time of treatment may have contributed to the lack of strong treatment effects in Spanish, as will be discussed below. Our findings are also consistent with the second pattern of cross-language generalization reported above, that is, the lack of cross-language generalization from a speaker's non-L1 language to his or her L1 (e.g., Miertsch et al., 2009). We found substantial and significant improvement in English following treatment in English, as well as modest improvement in two of the non-treated languages, French and German, two non-L1 languages in which JM had better skills than in the treated English. By contrast, we found no cross-language treatment effects to Spanish, JM's first and most proficient language.

Two additional findings are worth noting. One concerns the role of cognates in cross-language facilitation and inhibition. The items we used in the picture naming tasks comprised varying proportions of cognates between each language pair. Consistent in part with previous findings (e.g., Kohnert, 2004), we noted a facilitation effect of cognates. Specifically, cognates of the treated language were more often correct than incorrect in the non-treated languages. However, we also found that following the English treatment, the target words that were code-switched to English during testing in French and German were rarely cognates of English words, which is consistent with an overall activation of English words (as a result of English being the language of treatment and of the environment), not with a specific cognate effect.

The other, related finding concerns the differential effect (mentioned briefly above) of treatment in English on performance on picture naming versus on narrative production in the non-treated languages. Accuracy of French action naming decreased and the number of words produced in English during testing in French increased following treatment in English (but not following treatment in Spanish). A similar pattern was evident for German, with increased number of code-switches to English following English treatment. We interpret these results as evidence for competition in naming between two languages that share a large number of cognates and that are close in their levels of proficiency as well as in age of acquisition. In contrast to this evidence of cross-language inhibition, when treatment generalization was measured by the analysis of JM's picture-elicited narrative production, evidence for cross-language facilitation was now observed from English to both non-treated, non-L1 languages. We hypothesize that processes of competition between languages are likely to occur during testing that comprises word production using the same items in related languages tested on consecutive days, but that such processes do not inhibit production during narrative generation. It is possible that varying results across studies of cross-language treatment effects can be explained, at least in part, by the types of outcome measures employed. These potentially competing processes of inhibition and facilitation across multiple languages are fertile ground for further study.

Additionally, we found differences in results not only between the picture-naming tasks and the BAT, but also among the BAT subtests, suggesting that these subtests are differentially sensitive to language changes following treatment. Specifically, on the Fluency subtest JM demonstrated greater difficulty in German compared to other languages, in contrast to other measures on which German and French were comparable and better than English. Moreover, performance on the Sentence Construction subtest, comprising few items, did not appear to correspond to other subtests in a) distinguishing levels of proficiency and b) capturing change post-treatment. Furthermore, we suggest that additional aspects of the narratives elicited by the panel of pictures used in the Description subtest (beyond those suggested in

the BAT manual) can be analyzed – for example, grammaticality of the sentences produced and the lexical items used – to identify change in language production abilities.

On the basis of the patterns of results outlined above, one may conclude that two main variables, language status – whether a given language is the first language or not – and relative language proficiency, account for findings of cross-language treatment effects. In addition, we suspect that the language of environment at the time of treatment contributes to the treatment efficacy. In the present case, both phases of treatment were provided when the participant was in an English-speaking environment, one different from his typical environment. This may explain the limited change we noted in Spanish following treatment in Spanish in contrast to the significant changes in English following treatment in English. That is, JM's Spanish may have been less active and more inhibited than his English during his stay in New York and his immersion in an English-speaking environment (he did not have much chance to interact with Spanish-speaking relatives or friends during his stay there). In previous studies reported in the literature, the language of environment does not typically change for the duration of the treatment, but, consistent with our findings, Fredman (1975) results showed that treatment in L2 in an L2 environment resulted in cross-language generalization. The support provided by the environment to JM's relative higher activation of English following treatment is consistent with Paradis' notion of activation threshold (e.g., Paradis, 1993). In contrast, the activation of JM's Spanish was reinforced by the Spanish treatment but not by the environment. This difference between the two languages was compounded by the relatively high performance JM had in Spanish at the beginning of our study as compared to the lower performance in English, allowing for a greater change in his English skills than in Spanish. Finally, it is possible that language-specific characteristics and the shared vocabularies of JM's languages also contributed to the pattern of results. We note that all three factors – language proficiency, shared vocabulary, and language of environment – could combine to account for the differential effects of English treatment versus Spanish treatment on the two non-treated languages.

The study has several limitations. First, generalizations from a single participant to the larger population of multilingual individuals with aphasia should, of course, be made with caution. As well, we cannot rule out the possibility that the Catalan treatment preceding our study may have influenced JM's performance in his remaining languages; for example, JM's performance during the pre-Spanish testing – which we used to compare to his post-Spanish performance – may have been different from his performance prior to the Catalan treatment.

Conclusion

Administering treatment in one of the languages of polyglot speakers can result in selective effects on the non-treated languages. These effects may depend on the relative pre- and post-CVA language proficiency, the degree to which the languages in question share linguistic elements, and the degree to which the languages are dominant in the environment at the time of treatment. Data from additional multilingual individuals with aphasia who participate in treatment in their different languages can help dissociate the relative contribution of these variables. Results also depend on the measurements used to track change following language treatment. The comparable versions of the Bilingual Aphasia Test assist in measuring the same skills across languages.

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Appendix A

	Target in English	Target in Spanish	Target in French	Target in German	Treated in Spanish	Treated in English	Not treated
Objects							
	anchor	ancla	ancre	Anker	0	0	1
	arrow	flecha	flèche	Pfeil	0	0	0
	ax	hacha	hache	Axt	0	0	1
	bee	abeja	abeille	Biene	0	0	0
	bird	pajaro	oiseau	Vogel	0	1	0
	box	caja	boite	Schachtel	0	0	0
	brain	cerebro	cerveau	Gehirn	1	0	0
	bucket	cubo	seau	Eimer	0	0	0
	bus	autobus	autobus, bus	Bus	1	0	0
	butterfly	mariposa	papillon	Schmetterling	0	0	0
	cherry	cereza	cerise	Kirsche	0	1	0
	church	iglesia	église	Kirche	1	0	0
	clown	payaso	clown	Clown	0	1	0
	cork	tapon	bouchon	Kork	1	0	0
	cow	vaca	vache	Kuh	0	0	0
	crack	grieta/rajadura	fissure	Riss, Sprung	0	0	1
	curtain	cortina	rideau	Gardine	0	0	1
	dog	perro	chien	Hund	1	0	0
	drum	tambor	tambour	Trommel	0	0	1
	duck	pato	canard	Ente	1	0	0
	elephant	elefante	éléphant	Elefant	0	0	0
	envelope	sobre	enveloppe	Umschlag	1	0	0
	feather	pluma	plume	Feder	0	0	0
	fence	valla/cerca	barrière	Zaun	1	0	0
	flower	flor	fleur	Blumen	0	0	0
	frog	rana	grenouille	Frosch	1	0	0
	fruit	frutas	fruit	Gefruechte	0	0	1
	flag	bandera	drapeau	Fahne	1	0	0
	grapes	uvas	raisin	Weintraube	0	0	0
	hair	cabello/pelo	cheveux	Haare	0	0	0
	hat	gorra/sombrero	chapeau	Hut, Muetze, Kappe	0	1	0
	judge	juez	juger	Richter	0	0	1
	kitchen	cocina	cuisine	Kueche	1	0	0
	knot	nudo	noeud	Knoten	0	0	0
	ladder	escalera	échelle	Aufsteigsleiter, Leiter	0	0	0
	leg	pierna	jambe	Beine	0	0	0
	letter	carta	lettre	Briefe	0	1	0

Target in English	Target in Spanish	Target in French	Target in German	Treated in Spanish	Treated in English	Not treated
library	biblioteca	bibliothèque	Bibliothek	0	0	1
moon	luna	lune	Mond	1	0	0
mouse	raton	souris	Maus	0	0	1
nest	nido	nid	Nest	1	0	0
nun	monja	religieuse, nonne	Nonne	0	0	1
office	oficina/trabajo	bureau (lieu de travail)	Buro, Amt	0	0	1
pig	cerdo	cochon	Schwein	0	1	0
plug	enchufe	prise	Stecker	1	0	0
pocket	bolsillo	poche	Tasche	0	1	0
pond	laguna/lago	étang	Teich	1	0	0
rake	rastrillo	rateau	Rechen	0	0	1
roof	tejado	toit	Dach	0	1	0
saddle	silla de montar	selle	Sattel	0	0	1
sheep	oveja	mouton	Schaf	0	1	0
shorts	pantalones cortos	short	Unterhose, kurze Hose	0	0	0
spoon	cuchara	cuillère	Loeffel	0	0	1
square	cuadrado	carré	Quadra	0	1	0
stamp	sello/estampa	timbre	Briefmark, Stempel	0	0	1
stool	taburete	tabouret	Hocker	0	0	1
tank	tanque	tank	Panzer	0	0	1
tent	tienda/carpa	tante	zelt	0	0	0
tie	corbata	cravate	Krawatte	1	0	0
tiger	tigre	tigre	Tiger	0	1	0
tractor	tractor	tracteur	Traktor	0	0	1
tray	bandeja	plateau	Tablett, Schale	0	0	0
triangle	triangulo	triangle	Dreieck	0	1	0
waitress	mesera	serveuse	Kellnerin	1	0	0
watch	reloj	montre	Armband, Uhr	1	0	0
weight	pesa/masa	poids	Gewicht	0	1	0
wheel	rueda	roue	Rad	0	1	0
witch	bruja	sorciere	Hexe	0	1	0
brush	cepillo	brosse	Buerste	0	0	0
finger	dedo	doigt	Finger	0	1	0
shadow	sombra	ombre	Schatten	0	1	0
garden	jardin	jardin	Garten	0	1	0
Actions						
bark	ladrar	aboyer	bellen	0	1	0
bend	rebuja	se courber, se pencher	biegen	0	0	0

Target in English	Target in Spanish	Target in French	Target in German	Treated in Spanish	Treated in English	Not treated
blow	soplar	souffler	blasen	0	0	1
carry	cargar	porter	tragen	1	0	0
cross	cruzar	traverser	kreuzen	0	1	0
dig	cavar	creuser	graben	1	0	0
dive	zambulliar	plonger	tauchen	0	0	1
dream	soñar/dormir	rêver	trauemen	0	1	0
drive	guiar/conducir	conduire	fahren	0	0	0
fish	pescar	pêcher	fischen	1	0	0
float	flotar	flotter	floessen	1	0	0
fold	doblar	plier	falten	0	0	0
juggle	hacer malabarismos	jongler	jonglieren	0	0	1
kick	chutar/dar patadas	donner coup de pied	treten	0	1	0
kneel	arrodillar	se mettre à genoux	knien	0	0	0
knock	tocar/picar	frapper porte, tocquer	klopfen	0	0	1
lean	apoyar	se pencher, s'appuyer	lehnen	0	0	1
lick	lamer	lécher	lecken	0	0	0
melt	derritir	fondre	schmelzen	0	1	0
open (close)	abrir/serrar	ouvrir	oeffnen	0	1	0
peel	pelar	éplucher	schaelen	0	0	1
pinch	pellizcar	pincer	kneifen	0	0	0
pour	vertir	verser	giessen	0	1	0
pull	arrastrar	tirer	ziehen	1	0	0
push	empujar	pousser	schieben, stossen	0	1	0
rake	rastrillar	ratisser	rechen	0	0	1
ride	montar caballo	voyager á cheval	reiten	0	0	1
roar	rugir	rugir	bruellen	1	0	0
rock	mecer	balancer, bercer	schwanken	1	0	0
shoot	disparar/cazar	tirer (arme)	schiessen	1	0	0
smile	sonreir	sourire	laecheln	0	0	1
snow	nevar	neiger	schneien	0	1	0
stir	remover	mélanger, remuer	ruehen	0	0	0
stop	parar	arrêter	anhalten	0	0	1
stroke(pet)	acariciar	caresser	streicheln	1	0	0
swing	columpiar/balancearse	balancer	schaukeln	0	0	0
touch	tocar	toucher	tasten	0	0	0

Target in English	Target in Spanish	Target in French	Target in German	Treated in Spanish	Treated in English	Not treated
wash	lavar	laver	waschen	1	0	0
wave	saludar	saluer	winken	0	1	0
weave	tejer	tisser	weben	0	0	0

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Figure 1.
Naming Accuracy in Four Languages across Three Testing Times. Top: Object Naming;
Bottom: Action Naming

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Table 1

JM’s Relative Proficiency in Four Languages

	Self Rating		BAT Subtests						Picture Naming	
	Pre stroke	Pre-treatment	Letter Fluency	Semantic Opposites	Sentence Construction	Description #Words	Description #Clauses	Description #Grammatical Clauses	Object	Action
	Spanish	Spanish	Spanish	Spanish	Spanish	Spanish	Spanish	Spanish	Spanish	Spanish
Best ↓ Worst	French/German	German	English/French	English/French	English/French	German	German	German	German	French/German
		English				French	French	English/French	French	
	English	French	German	German	German	English	English	English/French	English	English

Table 2

JM's performance on the BAT subtests

Description							
	Letter Fluency	Semantic Opposites	Sentence Construction	#Clauses	#Grammatical Clauses	#Words	#nouns #verbs
Pre-Spanish Treatment							
Spanish	17	7	4	12	9	67	17 15
French	9	4	1	3	1	12	5 3
German	3	1	0	4	0	25	7 5
English	9	4	1	1	0	2	2 0
Post-Spanish Treatment							
Spanish	19	6	4	14	11	84	18 19
French	10	4	2	6	1	35	9 8
German	3	1	2	8	0	34	8 6
English	3	4	1	2	0	7	3 0
Post-English Treatment							
Spanish	18	6	3	12	8	80	17 16
French	9	4	2	9	2	34	8 11
German	7	1	1	10	3	49	16 7
English	6	5	3	12	4	75	20 11