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Cross-language treatment generalisation:

A case of trilingual aphasia

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Abstract

Background—Recent investigations of language gains following treatment in bilingual individuals with chronic aphasia appear to confirm early reports that not only the treated language but also the non-treated language(s) benefit from treatment. The evidence, however, is still suggestive, and the variables that may mitigate generalisation across languages warrant further investigation.

Aims—We set out to examine cross-language generalisation of language treatment in a trilingual speaker with mild chronic aphasia.

Methods & Procedures—Language treatment was administered in English, the participant's second language (L2). The first treatment block focused on morphosyntactic skills and the second on language production rate. Measurements were collected in the treated language (English, L2) as well as the two non-treated languages: Hebrew (the participant's first language, L1) and French (the participant's third language, L3).

Outcomes & Results—The participant showed improvement in his production of selected morphosyntactic elements, such as pronoun gender agreement, in the treated language (L2) as well as in the non-treated French (L3) following the treatment block that focused on morphosyntactic skills. Speech rate also improved in English (L2) and French (L3) following that treatment block. No changes were observed in Hebrew, the participant's L1.

Conclusions—Selective cross-language generalisation of treatment benefit was found for morphosyntactic abilities from the participant's second language to his third language.

Keywords

Aphasia; Trilingual; Treatment; Cross-language generalisation; Morphosyntax

Recent investigations of gains following language treatment in bilingual individuals with aphasia (e.g., Edmonds & Kiran, 2006) are consistent with early reports (e.g., Paradis, 1993; Watamori & Sasanuma, 1978) that not only the treated language but also the non-treated language(s) benefit from intervention. However, the evidence is still suggestive, and the variables that may mitigate generalisation across languages warrant further investigation.

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Cross-language treatment generalisation may depend on the status of the treated language; that is, whether the treatment is provided in the person's first language (L1) versus the second language (L2) or in the dominant language versus the less-dominant language. For example, Edmonds and Kiran (2006) found cross-language generalisation only when the non-treated language was the speaker's more dominant language or when the participants were highly proficient in both their languages. Edmonds and Kiran administered naming treatment to two bilingual individuals. Their first participant, who was dominant in English and less proficient in Spanish, demonstrated improvement only in the treated language when treated in his dominant language (English), and improvement in both the treated and the non-treated languages when treated in his less dominant language (Spanish). Their second participant was a balanced bilingual. He was treated in Spanish only and demonstrated improvement in both the treated and the non-treated languages. The authors attributed this difference in their participants' response to treatment to the difference in their dominance level of the non-treated languages.

Studies have also shown that cross-language generalisation might be limited to those linguistic aspects that are common to the two languages under investigation. For example, Kohnert (2004) found differential results for cognates (i.e., translation equivalents that share their meaning and form) as compared to non-cognates (i.e., translation equivalents that share their meaning but differ in form). These results are consistent with the unique role of cognates in the bilingual lexicon (e.g., Lalor & Kirsner, 2001). Furthermore, specific characteristics of the language components being treated might determine the patterns of impairment and recovery observed in each language. For example, Ullman and his colleagues (e.g., Ullman, 2006; Ullman et al., 2005) have proposed that syntactic aspects, hypothesised to be acquired implicitly (via procedural memory) in L1 but explicitly (via declarative memory) in L2 and other non-L1 languages (at least for late learners), are likely to have independent representation in the two languages. In contrast, the lexicon, hypothesised to be part of the declarative memory system in L1 as well as in L2 and other non-L1 languages, is suggested to have greater overlap in the two languages. An increasing amount of clinical and neuroimaging data supports the distinction and the localisation of the two memory systems in distinct neural networks (e.g., Friederici, 2004; Friederici, Hahne, & von Cramon, 1998; Ullman et al., 2005).

It is reasonable to assume that the representation and processing of linguistic aspects that are common to two languages would overlap more than the representation and processing of aspects that differ across languages and would thus potentially facilitate cross-language generalisation. Moreover, neuroimaging data from bilingual speakers suggest overlapping systems for the two languages of highly proficient bilinguals (e.g., Chee, Tan, & Thiel, 1999; Perani & Abutalebi, 2005). Further discussion of language representation and processing in the multilingual brain is beyond the scope of this paper (for reviews see Abutalebi, Cappa, & Perani, 2001; Abutalebi & Green, 2007; Paradis, 2004; Roberts, 2008; Vaid & Hull, 2002), yet assumptions concerning the dissociation between separate and shared representations in the languages of bilingual and multilingual individuals could yield predictions regarding cross-language generalisation, and guide clinicians' choices about which language to treat.

The question of which language to treat has received little mention in the research literature (e.g., Gil & Goral, 2004; Paradis, 1983). From a clinical standpoint, bilingual individuals who have aphasia ought to receive treatment in any and all their languages, but this is rarely feasible. For many bilingual individuals who live in their L2 environment, speech-language treatment is often available only in their L2. This is true for many individuals living in countries in which the primary language(s) spoken is not their first language, including, for example, the United States (e.g., Levy et al., 2007; Wiener, Obler, Taylor-Sarno, 1995), the UK and Scotland (e.g., Mennen & Stansfield, 2006; Winter, 1999), Australia (e.g., Diaz, 2003), and East Africa (e.g., Jochmann, 2006). Therefore it is critical to determine whether treating individuals' L2 can

yield positive outcomes in their L1 (or any other languages they speak) and if so, what language components are most likely to benefit from treatment. This information is required for the appropriate selection of the language or languages of treatment.

In the present study we employed a within-participant design to examine cross-language generalisation in aphasia treatment. We enrolled a trilingual speaker with aphasia, administered language treatment in English (L2), and tested his three languages pre- and post-treatment. We predicted that the participant would show treatment-related gains in the skills addressed in the treated language (his L2). In addition, we predicted that if languages of high proficiency are represented and processed in largely overlapping neural networks, we should observe cross-language generalisation for treatment gains to the participant's non-treated L1 (Hebrew) and L3 (French). If, however, language status (i.e., being the first- versus later-acquired language, being the more- or less-proficient language) affects language representation and therefore the occurrence of cross-language treatment generalisation, differential patterns would be detected for the non-treated L1 (Hebrew) versus the non-treated L3 (French).

METHOD

Case details

EC, a 49-year-old right-handed trilingual Hebrew-English-French speaker with chronic mild nonfluent aphasia participated in this study. Prior to his stroke EC had completed a doctorate and post-doctoral work in physics, and worked as the director of a computer animation company he founded. EC has not returned to work since his stroke. EC's first language was Hebrew, acquired from birth. He achieved native-like proficiency in Hebrew and used it extensively as a young adult and infrequently during the decade prior to his aphasia onset. His second language was English. He was exposed to English in infancy, as he was born in the US (although to Hebrew-speaking parents). After moving to Israel at age 3, he did not speak or hear English until he began learning it formally at school at the age of 10. Starting in his early 20s he began using English extensively while pursuing his higher education and later working in the US in the years prior to the aphasia onset. French was his third language, learned formally beginning at 16 and then used extensively during his post-doctoral studies and work in France, where he lived for approximately 15 years. At the time of the aphasia onset, French was the language used at home for communication among EC's family members. Reportedly, EC had achieved very high proficiency in all modalities in these three languages. In addition he enjoyed learning languages and had working knowledge of Spanish, German, and Italian. For a summary of EC's language history, see Table 1.

At age 42, EC experienced a left MCA CVA, resulting in a large fronto-temporoparietal lesion. In the 6 months immediately following his stroke, he experienced right hemiplegia and severe deficits in all languages. With time, his right-sided weakness resolved and he demonstrated steady improvement in his three languages. According to self-report, confirmed by our pre-treatment testing using the Bilingual Aphasia Battery (BAT, Paradis & Libben, 1987; see Figure 1), his Hebrew recovered better than the other two languages (despite infrequent use for a decade pre-onset) and his French recovered least (despite high proficiency and frequent use). (For additional information about EC's abilities in his three languages see Goral, Levy, Obler, & Cohen, 2006.)

Prior to the treatment provided in the course of the current study EC had received individual treatment in English for 5 months immediately following his stroke. About 1 year following his stroke he started to attend an aphasia support group, in which he continues to participate twice a week. At the time of the study, EC had been using the computer for email exchanges and Internet browsing, listening to books on tapes, and using a variety of workbooks in his

three languages. He demonstrated high motivation and dedication to improving his language abilities.

At the time the study began, 7 years post-onset, EC experienced mild aphasia, no hemiplegia, and no dysarthria. Informal assessment revealed no perceptual or cognitive impairment. His language comprehension was nearly intact. His oral language production was characterised by slow rate and frequent hesitations and rephrasing. He produced mostly complete sentences, but these were filled with false starts, self-corrections, and some uncorrected grammatical errors. His word-finding abilities were good in isolation but he experienced word-finding difficulties during connected speech production.

Treatment design and details

Treatment—Treatment was conducted in EC's L2, English, by a native speaker of English. Therapy consisted of two 3-week periods of nine 1-hour sessions each with a break of 3 weeks with no treatment in between. We administered treatments with two different foci. The first treatment targeted morphosyntactic constructions (e.g., tense consistency, pronoun agreement, noun-verb agreement). The second treatment targeted language production rate. The treatment activities were similar in both treatment blocks and included a number of barrier activities, structured conversation, and verbal description of pictures. Because of EC's good comprehension skills and adequate production skills at the word and phrase level, our treatment focused on language production in sentence and discourse context. Furthermore, our approach to treatment emphasised informative exchanges between EC and the clinician. That is, our goal was to minimise drill-based exercises and maximise language production in meaningful contexts (e.g., Goral & Kempler, in press; Meinzer, Elbert, Djundja, Taub, & Rockstruh, 2007). To this end, in both treatment blocks we used an array of pictures or verbal stimuli, and a barrier. For each exchange, EC was instructed to select a stimulus (e.g., a photograph of a painting) and to produce connected speech to describe it. The clinician, in turn, tried to guess what stimulus was being described. For each array of stimuli, a range of responses (e.g., different descriptions of paintings) was acceptable. Therefore, EC's production was required to be informative in order for the clinician to be able to identify the selected stimulus. Typically, EC produced sufficient information for the exchange to be successful. When needed, however, the clinician clarified EC's utterance, modelling a complete and correct response. In the course of the session, EC and the clinician took turns describing stimuli and exchanging information.

The difference between the two treatment periods was primarily in the type of feedback and correction provided by the clinician. In the first treatment block (morphosyntax), the clinician corrected any morphosyntactic error that EC produced and modelled correct production. The clinician and EC engaged in explicit discussions of sentence structure, morphological rules, etc. For example, EC was instructed to select a picture from an array of two to five pictures and to describe it to the clinician. The clinician identified the picture that EC was describing, provided him with feedback about the grammaticality of his production, modelled the correct structures, and elicited EC's correct production. In the second treatment block (language production rate), materials and tasks similar to those used in the first treatment block were employed. During this block, however, the clinician did not address EC's grammatical and morphosyntactic errors but focused instead on proceeding with his sentence. She encouraged him to employ word-finding strategies, such as circumlocutions, and to continue with his sentence production, even if the target word was not successfully retrieved and if grammatical errors were produced. For example, EC was again instructed to select a picture from an array and describe it as fluently as he could. The clinician identified the picture that EC described and then provided feedback concerning his language production rate, word-retrieval rate, and his use of strategies to avoid long pauses.

We note that the treatment sessions included explicit discussion of morphosyntactic rules, language structures, and strategies. As such, the treatment not only provided EC with the opportunity to practise his language production skills but also addressed metalinguistic abilities.

Because the participant lived in California and the Hebrew-English and French-English bilingual researchers were in New York,[1] we implemented long-distance testing and therapy over the computer using Skype™. The (student) clinician (the third author) used a sound-treated booth at the Speech Production and Perception Lab at Teachers College, Columbia University. The participant used his home desktop computer. He and the clinician saw each other on the computer (Dell™ Optiplex GX520 Desktop Computer) screen using cameras (Logitech Quickcam© Pro 5000 webcam), and heard each other using headphones. Appointments were scheduled for the duration of the treatment and any materials needed were sent prior to the treatment period. The materials included packets of duplicated numbered picture stimuli so that EC and the clinician could refer to the same series of stimuli.

Assessment—Multiple baseline measurements were collected, allowing us to measure EC's morphosyntax and language production rate before and after each treatment block. We consider these multiple baselines because (a) we repeatedly measured treated and non-treated skills (morphosyntax and speech rate) prior to and following each treatment block (which focused on morphosyntax and language production rate, respectively), and (b) because we collected measurements in the treated language, English (L2), and in the two non-treated languages, Hebrew (L1) and French (L3). The same measurements were collected three times on each of five occasions: before treatment began (Baseline), following the first treatment block (Post Treatment 1), before the second treatment block and after a period of no treatment (Pre Treatment 2), following the second treatment block (Post Treatment 2), and 6 months after the end of the second treatment block (Follow-up). At each point of data collection we obtained three measurements on two or three consecutive days to confirm performance stability, each comprising several tasks. For the purpose of the present paper we report data from an elicited sentence production task.

For the elicited sentence production task (used for assessment only), we employed a selection of 60 pictures from the Sentence Production Program for Aphasia (SPPA; Helm-Estrabrooks & Nicholas, 2000) (the SPPA had not been used for treatment with EC). We used the picture stimuli from the SPPA but not the target responses provided in the SPPA manual. Instead, EC was directed to one picture at a time and instructed to describe in two sentences what he saw happening in the picture. (For example, he was shown the picture of a man in a swimming pool and a woman sitting at the edge of that pool. The clinician instructed him to describe in two sentences what was going on in the picture. EC said: "The man in the pool eh tell his wife: come in the pool and swim with me. The woman says: it's too cold for me"). Different subsets of 12 pictures were used in an alternating fashion for the three languages during the differing measurement points, yielding 24 sentences per administration in each language (for examples, see Appendix). Over the course of testing, the same picture stimuli were presented in the three languages.

Because EC's language skills were only mildly impaired, and because treatment targeted sentence production in discourse context, we chose to assess his language skills before and

[1]At this time post stroke, EC is no longer eligible for medically covered speech-language treatment. However, he has remained highly motivated and interested in working on his language skills and maintaining his multilingualism. He had expressed interest to the first author in participating in a treatment study that would focus on multilingual individuals with aphasia. Because the researchers (who, collectively, spoke his three languages) lived in a different state from EC, long-distance treatment via the Internet was determined to be the most feasible solution. He agreed to participate in the study when the possibility of employing the Internet to conduct the study long-distance was proposed to him.

after treatment with this rather open-ended task. In contrast to the standard administration of the SPPA, our aim was to examine EC's spontaneous sentence generation skills, rather than his ability to produce pre-determined sentence structures. The sentences EC generated were recorded and transcribed verbatim for analysis. The sentence production task allowed us to measure two aspects of EC's language production abilities: morphosyntactic accuracy and speech rate.

Analysis

Using the sentence elicited in each language we conducted the following two analyses. For each analysis, values for each sentence were obtained and means across the three measurements per occasion and across the five testing occasions were calculated.

Morphosyntactic coding—For this analysis each sentence produced by the participant in the sentence elicitation task was coded as "correct", "self-corrected", or "incorrect" on the following six morphosyntactic measures: Noun-Verb Agreement, Tense Consistency, Prepositions, Pronoun-Gender Agreement, Sentence Complexity, and Overall Accuracy. For French sentences, Noun-Article Agreement was also examined. The number of possible occurrences for each measurement ranged from 2 to over 44, with over 90% of all measures having a minimum of 10 possible occurrences.

- Noun-Verb Agreement: Because the only English verb conjugation that requires overt morphological marking is the third person singular in the present tense, only those cases were counted as an opportunity for agreement. We tallied the percentage of correctly marked verb agreement (e.g., "The man asks his wife ..."); that is, we calculated the number of instances of correct marking out of the number of opportunities to do so, multiplied by 100. For Hebrew and French sentences, possible occurrences included all persons and tenses because these languages mark verb agreement for different persons/genders.
- Tense Consistency: The percentage of times in which the participant maintained tense consistency across the two sentences he produced to describe a picture (e.g., "The man told his wife about the snow. He ask*ed* her ...") was examined.
- Prepositions: We tallied the percentage of correctly used prepositions out of all prepositions used (e.g., "The man asked: 'What is *in* the box?"').
- Pronoun-Gender Agreement: The percentage of correctly agreed pronouns was obtained for each sentence (e.g., "The man asked *his* wife.").
- Sentence complexity: We counted the proportions of complex versus simple sentences used across the total (24) sentences.
- Noun-Article Agreement: For the French production only, the percentage of correct agreement between the article and the noun following it (e.g., "*la* fille a dit ...") was examined.
- Overall Accuracy: Each sentence was marked as "correct", "self-correct", or "incorrect", taking into account the measures above plus word choice and other errors not included in the measures detailed above.

Speech rate (syllable-per-minute measurements)—This analysis allowed us to assess the participant's overall language production rate. Because his language production was largely accurate but extremely slow, characterised by frequent hesitations, false starts, and self-corrections, we were interested in examining the effect of language treatment on his production rate. Therefore, for this analysis the duration of each sentence produced in the sentence elicitation task was measured. Sound Forge (Sony) software was employed to compute the

duration of EC's sentences. Numbers were rounded to the nearest millisecond. Onset of speech (i.e., the beginning of a sentence or the end of a pause) was defined as a change in amplitude at the zero crossing of the waveform indicating the beginning of an utterance, whereas offset of speech (i.e., the end of a sentence or the beginning of a pause) was defined as a decrease in amplitude in the waveform corresponding to the end of an utterance, reaching the zero crossing. For each sentence we divided the duration in seconds by the number of syllables produced in the sentence to yield a syllable-per-minute measure. For the syllable count we included only the meaningful portion of the sentence, excluding false starts, repetitions, and fillers.

For each of the analyses, a trained research assistant who was a native speaker or a highly proficient speaker of the analysed language completed the data coding for all measurements. A second trained individual completed the coding for 2 (13%) of the 15 (three per each of five occasions) measurements. Inter-rater reliability for the transcriptions, morphosyntactic coding, sentence duration, and syllable count ranged from 85% to 99%.

Following the analyses we tabulated the values obtained per measurement and the means of the three repeated measurements per testing occasion. To assess change, we calculated the effect size (Beeson & Robey, 2006) of the difference between occasions. For example, to assess change following the first treatment block we subtracted the average of Baseline (Pre-treatment 1) from the average of Post-treatment 1 and divided the difference by the standard deviation of Baseline. Differences between two occasions that yielded an effect size greater than 1 are taken as substantial and reported here.[2]

RESULTS

Results will be described first for English (L2), the treated language, and then for Hebrew (L1) and French (L3).

English (L2), the treated language

Morphosyntactic coding—Following the first treatment block (morphosyntax), the accuracy of Noun-Verb Agreement increased from 57% to 73% (effect size=1.6), and of Pronoun Gender Agreement from 91% to 100% (effect size=1.8) (see Figure 2). In addition, the percentage of Overall Accuracy increased from 32% to 44% (effect size=1.2). The accuracy percentage of correct Tense Consistency, Prepositions, and the percentage of Complex Sentences used did not change.

Following the second treatment block (language production rate), the only change noted was an increase in the percentage accurate Preposition use from 72% to 85% (effect size=1.7). No other measures showed change following the second treatment block.

Speech rate—The number of syllables per minute (per sentence) increased from 37.84 to 46.36 (effect size=1.2), following the first treatment block (morphosyntax) (see Figure 3). There was no change following the second treatment block (language production rate) (from 38.86 to 40.15) (effect size <1).

The non-treated languages: Hebrew (L1)

Morphosyntactic coding—EC demonstrated high accuracy levels (ranging from 91% to 100%) on the measures analysed, with no marked change across measurements (see Figure 4).

[2]Previous studies of aphasia treatment in a single-participant design report larger effect sizes for trained items tested before and after treatment than the ones we found here. We assessed change using untrained items in a free sentence elicitation task and therefore would expect small effect sizes.

Speech rate—There was no significant change in the number of syllables per minute in Hebrew following the first or the second treatment blocks (from 74.41 to 75.99 and from 78.76 to 73.29, respectively) (see Figure 3).

The non-treated languages: French (L3)

Morphosyntactic coding—Following the first treatment block (morphosyntax), there was an increase in the accuracy rates in French for Prepositions from 78% to 95% (effect size=1.4); for Pronoun-Gender Agreement from 74% to 88% (effect size=2.1); and Tense Consistency from 68% to 83% (effect size=1.9) (see Figure 5). Overall Accuracy increased from 32% to 49% (effect size=2.9).

Following the second treatment block (language production rate), the only measures that showed change were Tense Consistency from 72% to 94% (effect size=2.8), and Overall accuracy from 26% to 49% (effect size=2.6).

Speech rate—As in English, the number of syllables per minute increased in French following the first treatment block (morphosyntax) (see Figure 3). The increase was from 44.77 to 51.86 (effect size=1.6). No significant change was noted following the second treatment block (language production rate) (from 43.31 to 49.77) (effect size <1).

DISCUSSION

In this study we contrasted two blocks of language treatment administered to a trilingual speaker with chronic nonfluent aphasia to examine how language status (cross-language generalisation to L1 vs to L3) and the language aspects being treated (morphosyntactic vs language production rate) influence cross-language treatment generalisation. The treatment was administered in English, the participant's second language. We collected pre-and post-treatment measurements in the treated language as well as in the two non-treated languages: the participant's first language, Hebrew, and his third language, French. The results demonstrated that in response to the first treatment block (morphosyntax), there was a small increase in accuracy rates for selected morphosyntactic components in English, the treated language. A small increase in English speech rate following the first treatment block was also found. These findings suggest that a treatment approach that emphasises informative exchanges between the client and the clinician yields positive outcomes in individuals with chronic aphasia. Furthermore, the treatments employed were, in part, metalinguistic in nature (e.g., explicitly addressing morphosyntactic rules), in accordance with the participant's mild impairment and his good metalinguistic skills.

Additionally, as in English, the treated language, increased morphosyntactic accuracy and speech rate following the first treatment block (morphosynatx) were found also in French, the participant's non-treated third language. These increases following the treatment block that focused on morphosyntactic skills in English are suggestive of cross-language treatment generalisation from L2 to L3. Two portions of the findings corroborate our assumption that the improvement in French can be attributed to the treatment in English. One is the fact that the increase in accuracy rates in Prepositions, Pronoun-Gender Agreement, and Tense Consistency in French were found following the first treatment period, the treatment that focused on such morphosyntactic elements, and were generally not found following the second treatment block in which the focus was on language production rate. The second is the finding that no improvement was found in the French rates of Article-Noun agreement,[3] a

[3]We note that, on average, 60% of the nouns analysed for the Article-Noun agreement in French were animate nouns and about 50% of EC's Article-Noun agreement errors were on animate nouns. Most nouns (mean 97%) were singular nouns.

morphosyntactic component that does not exist in English. This latter finding suggests that cross-language generalisation is more likely for language components that exist in both the treated and the non-treated languages than for components that differ in the two languages.

We note that the increase in English and French speech rate followed the first treatment block (morphosynatx) but not the second (language production rate). This suggests to us that, in part, the participant's speech rate is slowed by his struggle with morphosyntactic language components. Therefore treating morphosyntactic skills in individuals with non-fluent aphasia may not only enhance their grammatical production but also their production rate. In this case we argue that a treatment approach that targets specific language components can yield an improvement in functional communication. We acknowledge that the magnitude of change observed following treatment was small. We might have expected small effect sizes in our data because we measured the participant's performance on untrained items in a relatively open-ended task (compared to effect sizes obtained for trained items in a picture naming test, see, for example, Wright, Marshall, Wilson, & Page, 2007).

We did not find a significant increase in Hebrew morphosyntactic accuracy or speech rates following either treatment block. This finding can be explained by at least two factors. One is the high performance rate in Hebrew, the participant's first and most recovered language. That is, we can assume that cross-language generalisation was not found due to ceiling performance in Hebrew. This is true for the morphosyntactic measures we used. In contrast, the participant's speech rate in Hebrew (around 80 syllables per minute) is still well below typical speech rate (120-200 words per minute). Alternatively, it could be hypothesised that due to the status of Hebrew as the participant's first language, there was differential representation and processing of Hebrew and English, and therefore there was no cross-language generalisation between these two languages. Unlike for Hebrew, cross-language generalisation was found between English and French, the two languages that were non-L1. Certainly, English and French may be expected to have more shared structures and representations at the lexical level than English and Hebrew, due to shared origins. Yet the role of structural and lexical similarities in cross-language treatment generalisation is still largely undetermined. For example, lexical similarities were deemed to be critical in determining cross-language generalisation in Kohnert's (2004) study, whereas cross-language generalisation has also been documented for languages that share few structural and lexical elements (e.g., English and Japanese in Watamori & Sasanuma, 1978).

With respect to our predictions, we found that the participant showed treatment-related gains in the skills addressed in the treated language (L2). In addition, in contrast to the prediction that overlapping representation and processing of languages of high proficiency would lead to cross-language generalisation to both the participant's L1 and L3, we found treatment-related improvement only in French, the participant's L3, and not in L1, Hebrew. Rather, the prediction that language status affects the occurrence of cross-language treatment generalisation was supported by the data. That is, we found a differential pattern of cross-language generalisation for the non-treated L1 vs the non-treated L3. This difference in language status is confounded by a difference in degree of recovery of the two nontreated languages, as well as the structural relations between each language pair. Furthermore, the participant's near-ceiling performance on the Hebrew morphosyntactic structures precludes an unequivocal conclusion regarding cross-language generalisation to the participant's L1 (similar results are reported for L1 in Miertsch, Meisel, & Isel, 2009). To dissociate these factors, additional studies with bilingual and multilingual speakers of other sets of languages are warranted in which, for example, the two non-treated languages would be equally impaired or equally related to the treated language.

Our findings of cross-language generalisation from the participant's more-recovered language to a less-recovered language can be taken as inconsistent with Edmonds and Kiran's (2006)

findings. However, their study focused on lexical retrieval abilities, whereas our cross-language findings concerned morphosyntactic skills.

Our study has several limitations. Because of the near-ceiling performance on our morphosyntactic measures in Hebrew, and because of the differences in structural similarities among the three languages, it is difficult to ascertain the reason for the differential cross-language generalisation found for French and Hebrew. Furthermore, because we did not find improvement in the treated language following the second treatment block (language production rate), we were unable to fully contrast cross-language effects of the two treatment blocks. The small improvement we measured following treatment can be attributed to the assessment task we used (a sentence elicitation task, measuring performance on newly elicited sentences rather than trained items) and to a relatively short treatment period. Further study will be useful to answer these unresolved questions.

CONCLUSION

The data from this within-participant treatment study suggest a complex pattern of generalisation from the treated language to the non-treated languages of a trilingual speaker with mild chronic aphasia. Change in the speaker's morphosyntactic performance was noted in the treated language (English, L2), as well as in certain aspects of his production in the non-treated French, his third language. Clinically, the results of this study suggest that treating individuals in one of their languages (at least when emphasising informative exchanges and addressing metalinguistic aspects of language production) could benefit their non-treated language. The investigation of treatment effects in bilingual and multilingual individuals represents a fertile area of clinical research, which could help determine the efficacy of treating individuals with aphasia in their non-native language.

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APPENDIX

Examples of EC's responses to the elicited sentence task

English

(Responses to 12 pictures (pre-treatment 1, first baseline measurement)

SPPA Picture 17—Umm the old man ask his wife uhhh uhh can his wife to lie sofa. Uhhh uh the woman umm tell told her husband that she has a severe headache.

SPPA Picture 19—Uhh the young player umm had a homerun uhhh homerun. Ummm the the woman umm ummm umm the side umm ummm eh shouted: Homerun!

SPPA Picture 21—Don't uhhh uhh don't don't put in your mouth the corner. Ummm and the young woman tell her dog: Don't stay here in the apartment.

SPPA Picture 23—Ummm the young woman umm tell tell told her friends about last night. Ehhh emmm she had a wonderful night with her new boyfriend.

SPPA Picture 25—Umm Bill is uhh thinking about his trip. He doesn't look ehh to the wall uh ball.

SPPA Picture 47—Uhhh umm the dad uhhh tell his son about the soup that he ummm makes. And ehh the young boy thinks the soup that his dad is making is uhhh ummm is beer.

SPPA Picture 49—Uhhh the the young man fell from the ladder. He is confused.

SPPA Picture 51—Umm the old man uhh uhhh wants to drink red wine. He uhhh hates the ummm noodles that the his wife uhhh brings.

SPPA Picture 53—The doctor ummm ehhh umm show shows the the young patient uhhh the thermometer. The young doctor said says that he she doesn't want the thermometer.

SPPA Picture 55—Umm uhh play with me ummm umm poker. The old man uhh says to his wife: let's play.

SPPA Picture 77—The father wants to know ehh whether the his sons uhhh played basketball. The the Alan says to his father: eh I we uhh played through the ball eh to the basket.

SPPA Picture 79—The the young man ummm ask his father: what's what are you doing? I want you to uhh ummm work ehhh in my room.

Hebrew

17:

אה אה ה איש הזקן אה מראה ל אישה שלו את הספה. אה הוא אומר לה אה תש אה תשכבי על הספה.

19:

האיש אה הנער מרוצה מה אה מכה שהוא נתן לַ כדור בייסבול שלו אה ה כדור הבייסבול.

אה הוא אה אמר אה הוא צועק: אה אה "הומראן".

21:

הנערה אומרת לכלב: תישאר פה בבית. אני אה צריכה לצאת עם החבר שלי.

23:

ה ילדה מספרת על על הח על הח לחברה שלה אה אה מה היה אה ביום ש שעבר אה בין אה סיגל אה לחבר שלה. ה ה החברה שלה אומרת: תשתקי.

25:

ה ילד ה אה אה הילד שיש לו שריון על החזה אומר לילד ל חבר שלו אה אה אה תפסיק עם ה אה תפסיק עם ה חשיבה ה תיאורטית אה שלך. אה יש אה מתקרב לפה כדור.

47:

אה ה אבא אומר ל ילד שלו אה תביא לי מים. אה צריך להוסיף מים ל מרק.

49:

ה אמא אומרת ל ילד: תצלצל אפס אחד אחד אה תשע אחד אחד. אה תבקש אה תגיד להם ש אבא נפל.

51:

ה א הבעל שואל את האישה שלו אה למה צריך צריך אה אה אה צריך ה הלמה צריך שה מפה תהיה ה לוח השח שלי? אה האישה אומרת אה אה אה תפסיק לדבר שטויות.

53:

ה איש אה ה דוקטור אה מוציא את ה מודד חום ונותן ל נערה. אה הנערה אומרת: איכס

55:

האישה שואלת את הבעל שלה: אה אה אפשר לשחק איתך בקלפים? ה בעל שלה אומר: איזה משחקקלפ.. קלפים?

77:

האבא אומר: אה אני רוצה לשחק איתכם כדורסל. מה החוקים של משחקהכדורסל?

79:

ה האיש הזקן אומר לבן שלו יש לי אה אה תביא לי קרשים. אה אני אה חסר ליקרשרים קרשים אה אה ל גג של הבית ש ה הזה שאני בונה.

French

17—Euh la femme a dit à son mari euh tu as euh euh euh euh tu as la tête en bas et le et la jambe en haut. Et euh la le mari a dit pourquoi?

19—La le l'entraîneur l'entraîneuse a dit à son euh à son euh à sa euh membre de l'équipe euh euh bravo. euh alain (?) euh tu as euh famé (?)

21—La le chien a a dit à sa euh au a à la femme euh est ce que je peux euh manger le fruit?

Euh la femme a dit à son chien euh euh euh ces fruits euh ils sont euh euh c'est une peinture euh pas le vrai fruit.

23—Euh le la jeune femme a euh ra euh racontéà sa son amie euh euh euh le de euh euh de .... le la fête euh euh de de hier. Euh euh la le la copine a dit euh euh stp euh euh euh je euh euh euh veux euh que tu euh ra raconte moi encore euh euh euh stp euh donne un euh un .... Partons euh tout de suite un dehors dehors pour euh pour me raconter la suite.

25—Euh euh la le le garçon qui euh a le euh armoire (?)? .... euh le machin qui euh sur le la ventre euh a dit à son copain euh tu euh rêves. Euh le il y a une balle qui vient euh euh vers toi.

47—Euh euh la le père la le papa a dit à son fils, euh euh moi j'ai fait euh la soupe à deux personnes. Euh euh la fils a dit non papa.

49—Euh la femme a dit à son mari euh quel combien de euh euh arbres il y a? Euh euh le mari a dit il y a euh un arbre euh ombre.

51—Euh la le mari euh le la femme a dit à son mari c'est ton anniversaire. Euh euh euh j'ai euh cuisiné euh les nouilles.

53—La le médecin a dit à sa euh à une euh à la fille euh euh c'est une sucette. Euh euh euh mets ça euh dans dans ta bouche.

55—La femme a dit à sa à son mari: où est euh le chat. Euh le la le mari à dit euh le chat est sur mes ... jambes.

77—Le la père est dans ... la père a dit à ses fils euh euh euh quel est le score? Euh un fils a dit à son père euh c'est 0-0.

79—Euh la fils a dit à son papa quel euh modèle tu construis? Euh la le papa a dit à son fils euh euh ce modèle est euh euh est ta euh maison.

REFERENCES

Abutalebi J, Cappa S, Perani D. The bilingual brain as revealed by functional neuroimaging. Bilingualism: Language and Cognition 2001;4:179–190.

Abutalebi J, Green D. Bilingual language production: The neurocognition of language representation and control. Journal of Neurolinguistics 2007;20:242–275.

Beeson PM, Robey R. Evaluating single-subject treatment research: Lessons learned from the aphasia literature. Neuropsychological Review 2006;16:161–169.

Chee MWL, Tan EWL, Thiel T. Mandarin and English single word processing studied with functional magnetic resonance imaging. Journal of Neuroscience 1999;19:3050–3056. [PubMed: 10191322]

Diaz CJ. Latino/a voices in Australia: Negotiating bilingual identity. Contemporary Issues in Early Childhood 2003;4:314–336.

Edmonds L, Kiran S. Effects of semantic naming treatment on crosslinguistic generalisation in bilingual aphasia. Journal of Speech Language and Hearing Research 2006;49:729–748.

Friederici, AD. The neural basis of syntactic processes. In: Gazzaniga, M., editor. The cognitive neurosciences III. MIT Press; Cambridge, MA: 2004. p. 803-814.

Friederici AD, Hahne A, von Cramon DY. First-pass versus second-pass parsing processes in a Wernicke's and a Broca's aphasic: Electrophysiological evidence for a double dissociation. Brain and Language 1998;62:311–341. [PubMed: 9593613]

Gil M, Goral M. Non-parallel recovery in bilingual aphasia: Effects of language choice, language proficiency, and treatment. International Journal of Bilingualism 2004;8:191–219.

Goral M, Kempler D. Training verb production in communicative context: Evidence from a person with chronic non-fluent aphasia. Aphasiology. in press.

Goral M, Levy ES, Obler LK, Cohen E. Lexical connections in the multilingual lexicon. Brain and Language 2006;98:235–247. [PubMed: 16793130]

Helm-Estabrooks, N.; Nicholas, M. Sentence Production Program for Aphasia. Pro-Ed; Austin, TX: 2000.

Jochmann A. Speech and language treatment in East Africa. The ASHA Leader 2006;11(2):8–9. 32–33.

Kohnert K. Cognitive and cognate-based treatments for bilingual aphasia: A case study. Brain and Language 2004;91:294–302. [PubMed: 15533555]

Lalor E, Kirsner K. The role of cognates in bilingual aphasia: Implications for assessment and treatment. Aphasiology 2001;15:1047–1056.

Levy, ES.; Crowley, CJ.; Wagner, EM.; Downey, S.; Kastl, R.; Pleshivoy, Y., et al. SLP students with accents: University clinics' policies and practices; Poster presented at the American Speech-Language-Hearing Convention; Boston, MA. 2007;

Meinzer M, Elbert T, Djundja D, Taub E, Rockstroh B. Extending the Constraint-Induced Movement Therapy (CIMT) approach to cognitive functions: Constraint-Induced Aphasia Therapy (CIAT) of chronic aphasia. NeuroRehabilitation 2007;22:311–318. [PubMed: 17971622]

Mennen I, Stansfield J. Speech and language therapy service delivery for bilingual children: A survey of three cities in Great Britain. International Journal of Language and Communication Disorders 2006;41:635–652. [PubMed: 17079220]

Miertsch B, Meisel J, Isel F. Non-treated languages is aphasia therapy of polyglots benefit from improvement in the treated language. Journal of Neurolinguistics 2009;22(2):135–150.

Paradis, M. Reading on aphasia in polyglots. Didier; Montreal: 1983.

Paradis, M. Bilingual aphasia rehabilitation. In: Paradis, M., editor. Foundations of aphasia rehabilitation. Pergamon Press; Oxford, UK: 1993.

Paradis, M. A neurolinguistic theory of bilingualism. John Benjamins Publishing Company; Amsterdam: 2004.

Paradis, M.; Libben, G. The assessment of bilingual aphasia. Lawrence Erlbaum Associates Inc.; Hillsdale, NJ: 1987.

Perani D, Abutalebi J. Neural basis of first and second language processing. Current Opinion of Neurobiology 2005;15:202–206.

Roberts, PM. Aphasia assessment and treatment for bilingual and culturally diverse patients. In: Chapey, R., editor. Language intervention strategies for aphasia and related neurogenic communication disorders. 5th ed.. Lippincott, Williams & Wilkins; New York: 2008. p. 245-276.

Ullman MT. The declarative/procedural model and the shallow structure hypothesis. Applied Psycholinguistics 2006;27:97–105.

Ullman MT, Pancheva R, Love T, Yee E, Swinney D, Hickok G. Neural correlates of lexicon and grammar: Evidence from the production, reading, and judgment of inflection in aphasia. Brain and Language 2005;93:185–238. [PubMed: 15781306]

Vaid, J.; Hull, H. Re-envisioning the bilingual brain using functional neuroimaging: Methodological and interpretive issues. In: Fabbro, F., editor. Advances in the neurolinguistics of bilingualism. Forum; Udine, Italy: 2002.

Watamori TS, Sasanuma S. The recovery processes of two English-Japanese bilingual aphasics. Brain and Language 1978;6:127–140. [PubMed: 728781]

Wiener, D.; Obler, LK.; Taylor-Sarno, M. Speech/language management of the bilingual aphasic in a U.S. urban rehabilitation hospital. In: Paradis, M., editor. Aspects of bilingual aphasia. Elsevier; Tarrytown, NY: 1995. p. 37-56.

Winter K. Speech and language therapy provision for bilingual children: Aspects of the current service. International Journal of Language and Communication Disorders 1999;34:85–98. [PubMed: 10505149]

Wright HH, Marshall RC, Wilson KB, Page JL. Using a written cueing hierarchy to improve verbal naming in aphasia. Aphasiology 2007;22:522–536.

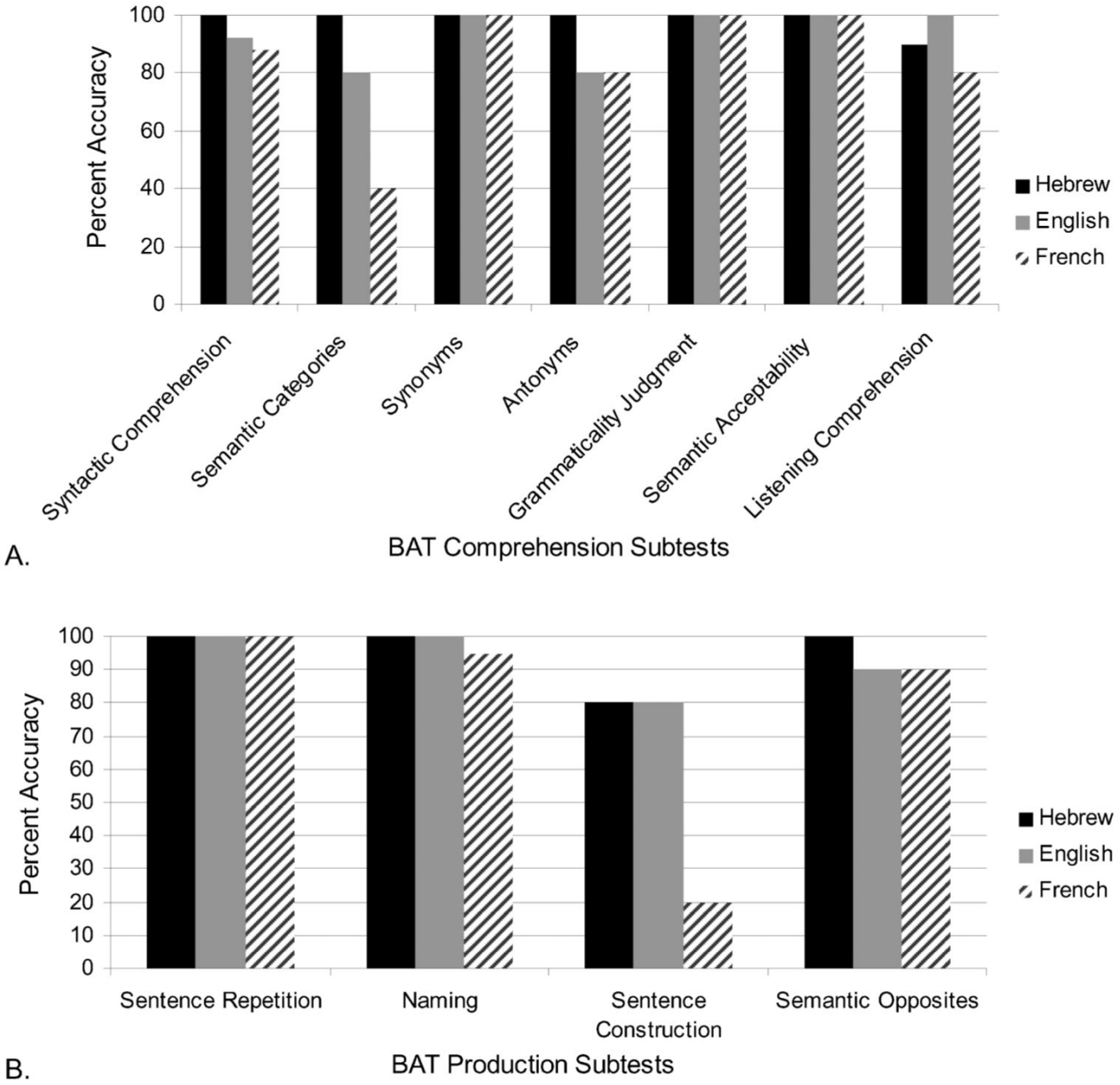

Figure 1.
Percent accuracy on the Bilingual Aphasia Test (BAT) Comprehension Subtests (A) and Production Subtests (B).

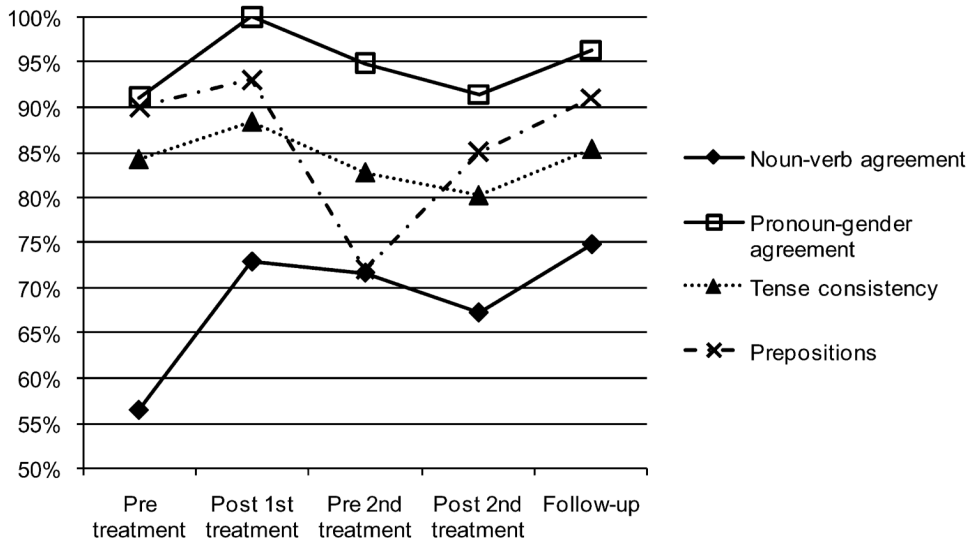

Figure 2.
Percent accuracy of morphosyntactic structures in English (L2, the treated language).

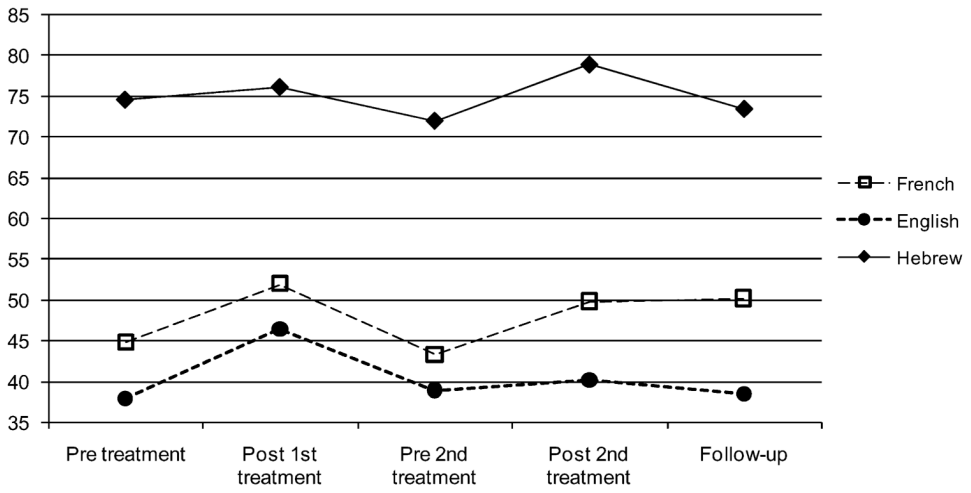

Figure 3.
Number of syllables per minute (on the Y axis) in the treated language and the two non-treated languages.

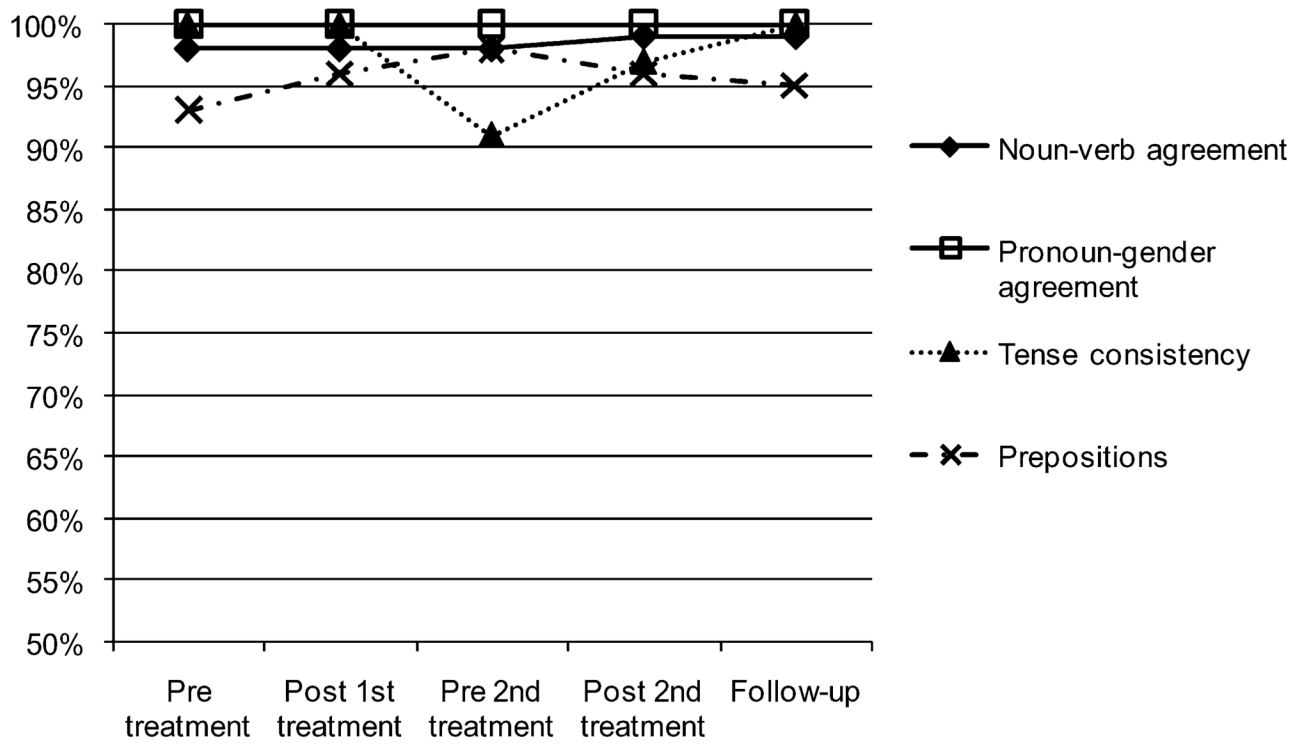

Figure 4.
Percent accuracy of morphosyntactic structures in Hebrew (L1, non-treated).

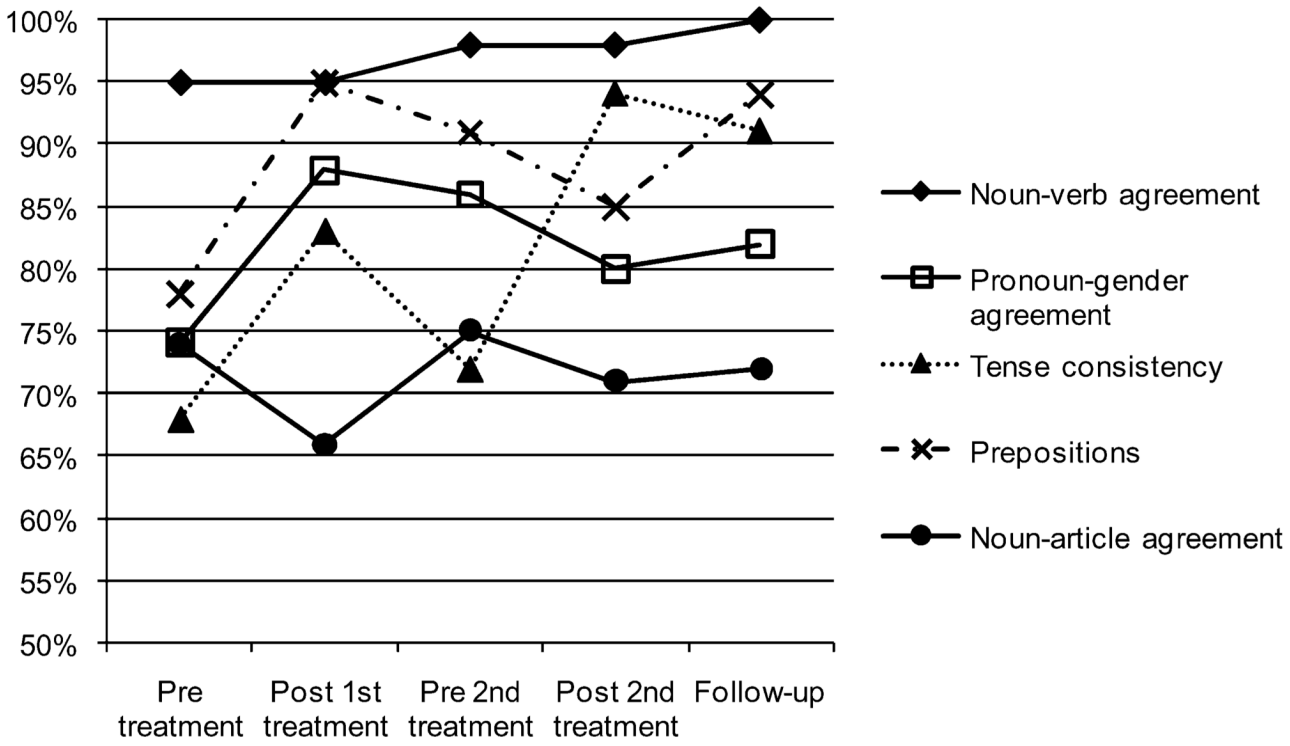

Figure 5.
Percent accuracy of morphosyntactic structures in French (L3, non-treated).

TABLE 1

Summary of EC's language history

	L1	*L2*	*L3*
Language	Hebrew	English	French
Age learned	Birth	Age 10	Age 16
How learned	Acquired at home	Exposed in infancy; learned formally; then by immersion	Learned formally; then by immersion
Language use at the time of aphasia onset	Rarely (with extended family)	Frequently (at work, with friends, in the environment)	Frequently (with immediate family at home)
Proficiency	High	High	High
Language use at time of treatment	Frequently (for practice)	Frequently (in the environment; for practice)	Frequently (with family; for practice)
Language of treatment	Non-treated language	Treated language	Non-treated language