Bilingual aphasia rehabilitation is of increasing interest since more than half the world's population is bilingual (Paradis, 1998). Although naming deficits have been reported extensively in bilingual aphasic individuals, the results of treatment studies for naming in bilingual aphasia (Galvez & Hinckley, 2003; Hinckley, 2003; Kohnert, 2002) have been equivocal. With regards to crosslinguistic generalization, cueing hierarchy treatments have revealed no crosslinguistic generalization for pairs of words (Galvez & Hinckley, 2003; Hinckley, 2003), and lexical-semantic treatment has resulted in crosslinguistic generalization for cognates only (Kohnert, 2002).

The present experiment attempts to address two unanswered questions in bilingual aphasia rehabilitation (Fabbro, 2001). First, is it sufficient to rehabilitate only one language? Second, does rehabilitation in one language have beneficial effects in the untreated language? We combined existing treatment methodologies for naming with theoretical models of bilingual language processing to guide treatment efforts for patients with bilingual aphasia. Our predictions were as follows:

1) *Trained items* (e.g., *apple*) will improve because semantic treatment will strengthen connections between the semantic representation and its corresponding phonological representation (Drew & Thompson, 1999; Kiran & Thompson, 2003).

2) Generalization to the *semantically related items* in the *trained language* (e.g., *orange*) will occur since monolingual aphasic individuals have demonstrated generalization to naming of untrained semantically related items (Drew & Thompson, 1999; Kiran & Thompson, 2003).

3) Generalization to the *translation of the trained item* in the *untrained language* (e.g., *manzana*) will occur since phonological representations of targets in both languages access a common semantic representation (De Groot, 1992).

4) Generalization to the *semantically related target* in the *untrained language* (e.g., *naranja*) was predicted based on the premise that strengthening semantic representations of a target in one language should improve access to the phonological representation of semantically related words in the untrained language.

Methods

Participants. Two patients with bilingual aphasia participated in the experiment. Both were at least eight months post-onset from a left perisylvian area CVA, were pre-morbidy right-handed and bilingual speakers of English and Spanish. Post-CVA they had equal levels of language impairment in both languages (based on *Bilingual Aphasia Test* (Paradis, 1989) and *The Boston Naming Test* (Kaplan, Goodglass, & Weintraub, 1983) test scores). Neither subject had hearing or visual impairments that interfered with treatment tasks. A language use questionnaire (Muñoz, Marquardt, & Copeland, 1999) was completed with each participant regarding pre-morbid language proficiencies. Ratings of comprehension and production abilities for both languages were used to calculate a pre-morbid bilingual proficiency ratio (BPR) (Average Spanish comprehension and production/Average English comprehension and production). Participant 1's (P1) BPR was .71, and Participant 2's (P2) was 1.1. When compared to groups of normal bilingual individuals who completed the same questionnaire (Edmonds and Kiran, 2004), P1 was deemed English dominant and P2 was deemed equally proficient.

Stimuli. For each patient, five stimuli sets were created, and all except the control set (n = 5) contained 10 items: English set 1 (e.g., *Table*), Spanish set 1 (e.g., *Mesa*), English set 2 (e.g., *Chair*), Spanish set 2 (e.g., *Silla*), Control Set (e.g., *Boat* either English/Spanish). Stimuli were matched for frequency across languages. Average word lengths were 1.52 for English and 2.63 for Spanish. A group of normal bilingual adults rated pairs of words for similarity of meaning on a scale of 1 (very similar) to 4 (not similar) in both languages (See Edmonds & Kiran, 2004) to determine appropriateness of semantic pairs (average=2.025).

Design. A single subject experimental multiple baseline design across participants and behaviors was used to examine generalization across languages and semantically related items within each language. Naming performance of the trained and untrained examples was assessed weekly prior to treatment.
Treatment. A semantic based treatment (Boyle & Coehlo, 1995; Kiran & Thompson, 2003) was employed. Treatment steps included: (a) naming the example, (b) identifying semantic attributes of the example (e.g., function, characteristics) (c) answering yes/no questions regarding these features, and (d) re-naming the target example.

Results

Naming accuracy
Participant 1. Following stable baselines, treatment was initiated on English items, which resulted in acquisition of trained items to criterion (80% accuracy). Generalization to semantically related words in English was observed. No crosslinguistic generalization was seen to either set of Spanish words. See Figure 1.

Treatment was then switched to Spanish set 2. Acquisition of trained items was clear (100% accuracy), but no generalization to semantically related words was observed. Performance on the untrained translations in English set 2 improved as did the originally trained English set 1. As expected, unrelated control items (N = 5 items in each language) did not demonstrate any change as a function of treatment.
Participant 2. Following stable baselines, treatment was initiated on Spanish items, which resulted in acquisition of trained items to 80% accuracy and generalization to untrained semantically related words in Spanish and to both sets in English. See Figure 2.
Error analysis
Participant 1. Errors during English probes before and after English treatment revealed a reduction of English perseverations/neologisms (36% to 0%) and unrelated responses (10.5% to 0%) with an increase in semantic errors (0 to 7.0%). Spanish errors showed little change (perseveration/neologisms: 21.6% to 24%; crosslinguistic errors: 7.2% to 3.8%). By the end of Spanish treatment, Spanish perseveration/neologisms (3.8%) and cross-linguistic errors (.5%) reduced while the proportion of no-responses (NR) increased (2.0% to 9.1%.) with few changes of English errors (perseveration/neologisms: 7.9% to 0%, NR: 7.0% to 2.5%).
Participant 2. Errors during English and Spanish probes revealed a decrease in NR errors (English: 63.0% to 13.4%; Spanish: 76.4% to 4.0%) and an increase in crosslinguistic errors (English: 1.7% to 16, Spanish: 7%0% to 15.6%) during Spanish treatment.

Discussion

Results of this experiment demonstrate the effect of a semantic based treatment on within and across languages generalization related to pre-morbid dominance patterns. P1 (English dominant) showed within language generalization when trained in English, but no crosslinguistic generalization was observed. With Spanish treatment, no within language generalization was seen, but crosslinguistic generalization to the dominant language occurred. Results of both patients can be explained by the mixed model of bilingual access (De Groot, 1992) which hypothesizes that the connections between the semantic system and each lexicon can vary with proficiency. Thus, the strengths of the connections between the semantic system and Spanish may not have been strong enough to support generalization for P1. Further, P1's error analysis revealed no change in error types in Spanish until he received Spanish treatment, indicating little processing in Spanish during English treatment. Additionally, P1's pre- and post-treatment test results revealed more improvements in English than in Spanish. See Tables 1-3.

P2 exhibited generalization within Spanish, the trained language, as well as to both sets of English words. Because she was pre-morbidly equally proficient, the strength of the connections between the semantic system and both lexicons were theoretically all relatively equal (De Groot, 1992), thus explaining the extensive generalization achieved. P2's error patterns revealed processing in both languages with Spanish treatment only, a finding consistent with her generalization patterns. Further, P2 showed improvement in pre- and post-testing in both languages. See Tables 1-3.

For patients with a language dominance, it may *not* be most efficacious to treat the dominant language since crosslinguistic generalization may be limited. However, a balanced bilingual may benefit from treatment in either language. The findings of this study are preliminary, and replications across dominances and languages are needed.

FIG. 1. Percent correct items on English and Spanish trained and untrained experimental probes during baseline and experimental sessions for Paricipant 1

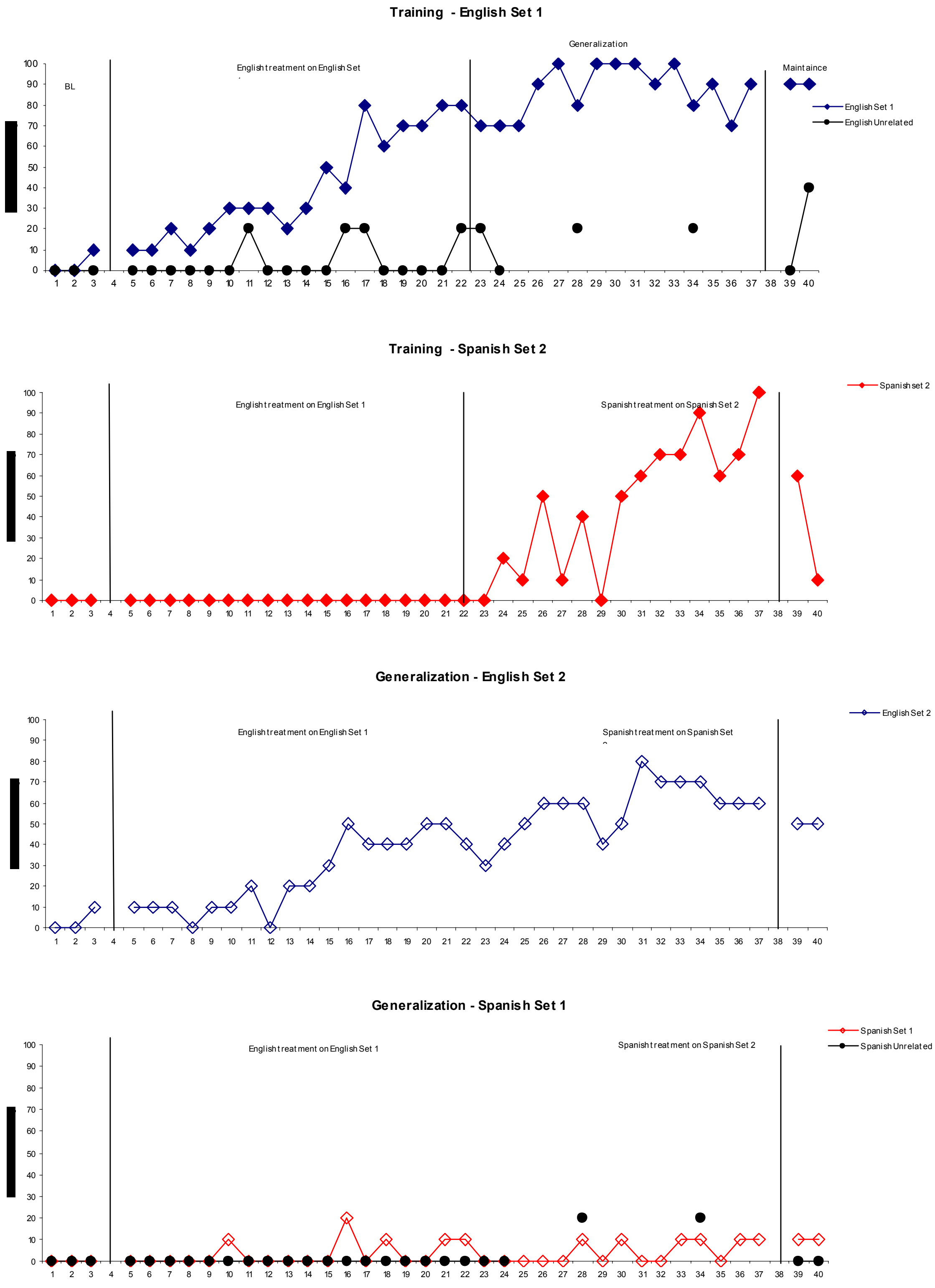

FIG. 2. Percent correct items on English and Spanish trained and untrained experimental probes during baseline and experimental sessions for Participant 2

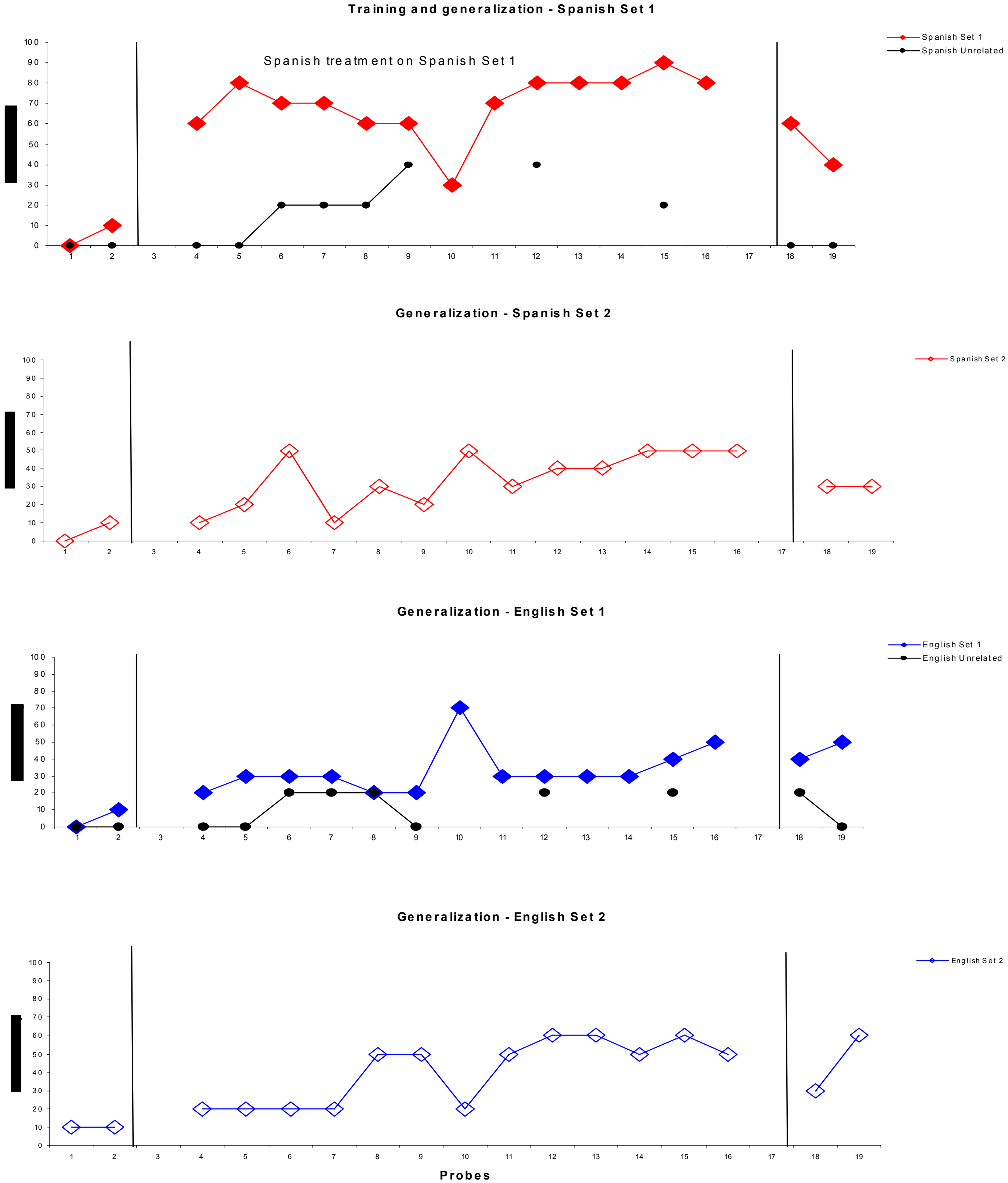

Table 1. Pre- and Post-language performance on tests administered in English only (*Western Aphasia Battery* (Kertesz, 1982) and *PALPA (*Kay et al., 1992))

	P1			P2		
Western Aphasia Battery (WAB)	Pre	Post	% change	Pre	Post	% change
Spontaneous speech (%)	20.0	40.0	**20.0**	60.0	65.0	5.0
Auditory comprehension (%)	47.0	61.5	**14.5**	79.5	88.5	9.0
Repetition (%)	27.0	38.0	**11.0**	65.5	74.0	6.5
Naming (%)	25.0	53.0	**28.0**	70.0	81.0	**11.0**
Aphasia Quotient (%)	27.0	38.0	**11.0**	67.5	74.7	6.8
PALPA						
Letter Length Reading (%)	0.0	58.3	**58.3**	75.0	91.7	**16.7**
Spoken Word-Picture Matching (%)	52.5	92.5	**40.0**	92.5	97.5	5.0
Written Word-Picture Matching (%)	77.5	95.0	**17.5**	92.5	97.5	5.0
Auditory Synonym Judgments (%)	48.3	DNT		73.3	81.7	8.3
Written Synonym Judgments (%)	66.7	76.7	10.0	70.0	70.0	0.0
Spoken Picture Naming (%)	2.5	DNT		67.5	82.5	**15.0**
Picture Naming:Writing Picture Names (%)	0.0	2.5	2.5	0.0	0.0	0.0
Picture Naming:Reading Picture Names (%)	0.0	0.0	0.0	80.0	90.0	10.0
Picture Naming: Repeating Picture Names (%)	92.5	95.0	2.5	92.5	100	7.5
Picture Naming: Spelling Picture Names (%)	0.0	0.0		0.0		
Spoken Letter-Written Letter Matching (%)	0.0	38.5	**38.5**	57.7	80.8	**23.1**

Numbers in bold font indicate a percent change of more than 10%. DNT = Did not test.

Table 2. Pre- and Post-language performance on tests administered in English and Spanish for Participant 1 (*Boston Naming Test* (Goodglass et al., 1983) and *Bilingual Aphasia Test* (Paradis, 1989)

	English			Spanish		
	Pre	Post	% change	Pre	Post	% change
Boston Naming Test (BNT) (%)	1.7	35.0	**35.0**	0.0	1.67	1.67
Bilingual Aphasia Test (BAT) Part B						
Pointing (%)	50.0	100	**50.0**	30.0	60.0	**30.0**
Verbal Auditory Discrimination (%)	61.1	72.2	**11.1**	50.0	50.0	0.0
Semantic Categories (%)	60.0	80.0	**20.0**	100	60.0	**-40.0**
Synonyms (%)	20.0	100	**80.0**	20.0	0.0	**-20.0**
Antonyms I (%)	20.0	60.0	**40.0**	0.0	40.0	**40.0**
Antonyms II (%)	20.0	40.0	**20.0**	60.0	0.0	**-60.0**
Semantic Acceptability (%)	70.0	60.0	-10.0	50.0	40.0	**-10.0**
Repetition	76.7	73.3	-3.34	66.7	DNT	n/a
Naming (%)	20.0	60.0	**40.00**	0.0	0.0	0.0
Sentence construction (%)	0.0	0.0	0.0	0.0	0.0	0.0
Semantic opposites (%)	0.0	0.0	10.0	0.0	0.0	0.0
Description (%)	0.0	42.9	**42.9**	0.0	DNT	n/a
Reading words (%)	0.0	70.0	**70.0**	10.0	10.0	0.0
Reading sentences (%)	0.0	0.0	0.0	0.0	0.0	0.0
Reading text (comprehension) (%)	0.0	16.7	**16.7**	0.0	DNT	n/a
Copying (%)	100	100	0.0	60.0	100	**40.0**
Dictation (%)	0.0	0.0	0.0	0.0	0.0	0.0
Reading comprehension (words) (%)	90.0	100	10.0	50.0	40.0	-10.0
Reading comprehension (sentences) (%)	30.0	80.0	**50.0**	40.0	50.0	10.0
Bilingual Aphasia Test (BAT) Part C						
Recognition of words (Spanish to English) (%)	40.0	80.0	**40.0**			
Recognition of words (English to Spanish) (%)	20.0	100	**80.0**			
Translation of words (Spanish to English) (%)	10.0	10.0	0.0			
Translation of words (English to Spanish) (%)	0.0	0.0	0.0			
Translation of sentences (Spanish to English) (%)	0.0	0.0	0.0			
Translation of sentences (English to Spanish) (%)	0.0	0.0	0.0			

Numbers in bold font indicate a percent change of more than 10%. DNT = Did not test.

Table 3. Pre- and Post-language performance on tests administered in English and Spanish for Participant 2 (*Boston Naming Test* (Goodglass et al., 1983) and *Bilingual Aphasia Test* (Paradis, 1989)

	English			Spanish		
	Pre	Post	% change	Pre	Post	% change
Boston Naming Test (BNT)	41.7	48.3	6.7	40.0	55.0	**15.0**
Bilingual Aphasia Test (BAT)						
Pointing (%)	100	100	0.0	100	100	0.0
Verbal Auditory Discrimination (%)	83.3	83.3	0.0	66.7	100	**33.3**
Semantic Categories (%)	100	80.0	**-20.0**	100	80.0	**-20.0**
Synonyms (%)	80.0	80.0	0.0	60.0	80.0	**20.0**
Antonyms I (%)	80.0	80.0	0.0	100	60.0	**-40.0**
Antonyms II (%)	60.0	100	**40.0**	80.0	80.0	0.0
Semantic Acceptability (%)	100	100	0.0	90.0	100	10.0
Repetition (%)	93.3	96.7	3.3	96.7	96.7	0.0
Judgment of words/nonwords (%)	56.7	90.0	**33.3**	66.7	100	**33.3**
Sentence repetition (%)	28.6	57.1	**28.6**	57.1	85.7	**28.6**
Series (automatics) (%)	66.7	66.7	0.0	66.7	100	**33.3**
Naming (%)	60.0	66.7	6.7	93.3	100	6.67
Semantic opposites (%)	20.0	40.0	**20.0**	10.0	50.0	**40.0**
Reading words (%)	80.0	70.0	-10.0	90.0	100	10.0
Reading sentences (%)	20.0	50.0	**30.0**	40.0	70.0	**30.0**
Reading text (comprehension) (%)	66.7	66.7	0.0	50.0	66.7	**16.7**
Copying (%)	60.0	80.0	**20.0**	DNT	100	n/a
Dictation (%)	0.0	0.0	0.0	DNT	20.0	n/a
Reading comprehension (words) (%)	80.0	80.0	0.0	80.0	90.0	10.0
Reading comprehension (sentences) (%)	30.0	30.0	0.0	40.0	50.0	10.0
Bilingual Aphasia Test (BAT) Part C						
Recognition of words (Spanish to English) (%)	100	100	0.0			
Recognition of words (English to Spanish) (%)	100	100	0.0			
Translation of words (Spanish to English) (%)	50.0	60.0	10.0			
Translation of words (English to Spanish) (%)	60.0	60.0	0.0			
Translation of sentences (Spanish to English) (%)	0.0	0.0	0.0			
Translation of sentences (English to Spanish) (%)	0.0	0.0	0.0			

References

Boyle, M., & Coehlo, C. (1995). Application of semantic feature analysis as a treatment for aphasic dysnomia. *American Journal of Speech-Language Pathology, 4*, 94-98.

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

Drew, R. L., & Thompson, C. K. (1999). Model-based semantic treatment for naming deficits in aphasia. *Journal of Speech, Language, and Hearing Research, 42*, 972-989.

Edmonds, L. A., & Kiran, S. (2004). Confrontation naming and semantic relatedness judgements in Spanish/English bilinguals. *Aphasiology, 18*(5/6/7)*,* 567-579.

Fabbro, F. (2001). The bilingual brain: bilingual aphasia. *Brain and Language, 79*(2), 201-210.

Galvez, A., & Hinckley, J. J. (2003). Transfer patterns of naming treatment in a case of bilingual aphasia. *Brain and Language, 87*, 173-174.

Hinckley, J. J. (2003). Picture naming treatment in aphasia yields greater improvement in L1. *Brain and Language, 87*, 171-172.

Kaplan, E., Gooidglass, H., &Weintraub, S. (1983). *Boston Naming Test*. Philadelphia: Lea and Febiger.

Kiran, S., & Thompson, C. K. (2003). The role of semantic complexity in treatment of naming deficits: Training semantic categories in fluent aphasia by controlling exemplar typicality. *Journal of Speech, Language and Hearing Research, 46*(4), 773-787.

Kohnert, K. J. (2002). *Cognitive and cognate treatments for bilingual aphasia: A case study.* Paper presented at the American Speech-Language-Hearing Association Annual Convention, Atlanta.

Muñoz, M., Marquardt, T., Copeland, G. (1999). A comparison of the codeswitching patterns of aphasic and neurologically normal bilingual speakers of English and Spanish. *Brain and Language, 66*, 249-274.

Paradis, M. (1989). *Bilingual Aphasia Test*. New Jersey: Lawrence Erlbaum Associates, Inc.

Paradis, M. (1998). Aphasia in bilinguals: How atypical is it? In A. Basso (Ed.), *Aphasia in Atypical Populations* (pp. 35-66). Mahway, NJ: Lawrence Erlbaum Associates.